AD-A057 374 JOINT TECHNICAL COORDINATING GROUP FOR MUNITIONS DEVE--ETC F/G 19/1
EVALUATION OF DOD REMOTE SET FUZING PROGRAMS FINAL REPORT ON JT--ETC(U)
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EVALUATION OF DOD REMOTE SET FUZING PROGRAMS

FINAL REPORT OF JTCG/WPFF AD HOC COMMITTEE

NOVEMBER 1977

DARCOM

NMC

AFLC

AFSC

PUBLISHED BY
JOINT FUZE TASK GROUP
DRCDE-JFTG
2800 POWDER MILL ROAD
ADELPHI, MD 20783

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER N/A	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) 6 Evaluation of DOD Remote Set Fuzing Programs Final Report on JTCG/WPFF Ad Hoc Committee.		5. TYPE OF REPORT & PERIOD COVERED 9 FINAL rept. [redacted] 6. PERFORMING ORG. REPORT NUMBER N/A
7. AUTHOR(s) Ad Hoc Committee on Remote Set Fuzing		8. CONTRACT OR GRANT NUMBER(s) N/A
9. PERFORMING ORGANIZATION NAME AND ADDRESS New 410801 ~~The Joint Logistics Commanders~~ Joint Technical Coordinating Group for Munitions Development ~~Working Party for Fuzes~~ ~~Ad Hoc Committee on Remote Set Fuzing~~		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS A7~~8~~A1
11. CONTROLLING OFFICE NAME AND ADDRESS Joint Fuze Task Group 2800 Powder Mill Rd. Adelphi, MD 20783		11 12. REPORT DATE Nov~~ember 1~~977 13. NUMBER OF PAGES 110
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 12 98p. 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

[redacted].

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

None

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Remote set fuzing, bombs, mortars, rockets, artillery

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A study was conducted by the Joint Technical Coordination Group Working Party for Fuzes on the current status of tri-Service remote set fuzing concepts. The study group concluded that several concepts were being investigated to satisfy a single need and that these parallel efforts were justified. The study group also concluded that there were no duplicative efforts and each concept selected for pursuit appeared to be the best choice made.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

410801 78 07 28 018

Several areas were identified that could lead to commonality between Army and Navy artillery fuzes. A joint agreement existed between the Navy and Air Force for commonality of future store management systems.

FOREWORD

This Technical Report was prepared for the Joint Fuze Task Group, a task force of the Fuze Management Board in the Joint Logistics Commanders Organization. Because the Services' fuze programs are dynamic and changing, the report represents the best data available to the task force at this time. The purpose of the report is to provide data on remote-set fuzing concepts, thereby promoting inter-Service awareness of the total Department of Defense remote-set fuzing efforts and their implications for commonality of future fuzing systems. By careful analysis of the data in this report, personnel (management and engineering) should be better able to determine technical voids and areas of potential duplication or proliferation.

The findings of this report are not to be construed as an official Department of Defense position, unless so designated by other authorized documents.

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ACKNOWLEDGEMENT

The JTCG/WPFF wishes to acknowledge the cooperation and support of the many organizations which provided the members to the ad hoc committee and also the information necessary to prepare this study.

The committee members also want to acknowledge the assistance of Barry Scheiner, HDL, who participated extensively in the writing and editing of the report and Frank Vrataric, JFTG, for his assistance in insuring that the report met the objectives of the JFTG.

CONTRIBUTORS

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1. INTRODUCTION

1.1 Background

The Fuze Management Organization (FMO) was chartered by the Joint Logistics Commanders to maximize the coordination of the Services fuze research, development and engineering programs for nonnuclear munitions. The FMO consists of a permanent Fuze Management Board (FMB) whose members are General and Flag officers representing the three Services, and a Joint Fuze Task Group (a temporary tri-Service working group) which is the action arm of the FMB.

The Joint Fuze Task Group (JFTG), as part of the FMO objective, identified a number of study tasks to resolve some questions which were raised in a fuze study report prepared by a committee chaired by MG Daniel with respect to potential duplication and proliferation. Remote-set fuzing was one of the candidate subjects identified for such a study, because it appeared that multiple efforts were being pursued on hardwire, acoustic, inductive, optical, radio frequency, and X-ray approaches to a data link.

The remote-set study task was assigned to the Joint Technical Coordinating Group/Munitions Division/Working Party for Fuzes (JTCG/MD/WPFF). The WPFF was tasked because: (a) it was familiar with the program and (b) it was initially intended that the JFTG functions would be transferred to the WPFF in the transition to a permanent fuze review body.

The JFTG expected that the experience gained by the WPFF, working under the JFTG charter, would then enable it to take over the JFTG functions at the designated time with a minimum of problems.

The WPFF formally accepted the task for those reasons and established an ad hoc committee, consisting of tri-Service members who were actually working on remote-set programs. However, at this time it is planned to transfer the JFTG functions to a group comprised of Service Fuze Managers. The future status of the WPFF is uncertain.

1.2 Scope

This report is the joint product of the ad hoc committee on remote-set fuzing and represents the consensus technical judgment of that committee. The report first outlines the scope of the study and defines the problem to be resolved by the study. This is followed by a description of the approach taken in examining the issues, and by the description and comparison of various remote-set systems, including both applications and technology base. Finally, the conclusions and recommendations of the Study Group are presented.

1.3 Summary

1.3.1 The Study Committee determined that four data links are being actively considered for current and planned developments. These are inductive, hardwire, rf and optical. The optical system is being developed by the Navy for the Advanced Aircraft Armament Stores (AAAS) system. It will provide a common data system for future aircraft stores in the 1990 time frame. The inductive, hardwire, and rf technologies are applied to a variety of helicopter, shipboard, tank, and field artillery communications, so that this appeared to be an area where duplication of effort could be reduced.

However, our study showed that there was generally a valid rationale for choosing different data links to meet the different requirements.

1.3.2 The Study Group concluded that, in general, the best technical approach has been chosen for programs currently in development and that the wide variations in technical, tactical, and physical requirements limited the commonality which could be achieved.

Other conclusions from the study were that:

There is little or no duplication of development efforts.

Competition is vital to insure technical advancement and the availability of alternative approaches.

No single data link is satisfactory for all classes of weapons.

Standardized components may yield some limited savings.

Standard software and data formats would increase commonality.

1.3.3 We consequently recommend the following, both to assure an adequate technology base and to reduce future proliferation of remote-set systems:

Continue current programs with data links chosen.

Distribute requirements early, through tri-Service points of contact for fuzing.

Fund multiple approaches in 6.2 and 6.3A, but closely monitor the rationale when choices are made for 6.3B and 6.4 programs.

Standardize software and data formats.

Consider preparation of a JSOR for remote setting of fuzes for Navy guns and fuzes for Army artillery weapons.

Provide a vehicle for continued coordination between remote-set developers. This study group provided the best vehicle for identifying possibilities for new applications of systems currently being developed.

2. HARMONIZATION CONSIDERATIONS

It was a goal of this study to determine the degree of proliferation and duplication in remote-set fuzing developments and remote-set systems between and within the Services, and to determine how this could be minimized in the future. A concern of the JFTG was whether the potential benefits of harmonization and commonality could be obtained, especially for systems contemplated for development in the near future. Harmonization requires coordination between the Services and awareness of existing and proposed systems to insure utilization of technology, experience, and hardware wherever

possible. For example, requirements documents should be written sufficiently general to allow consideration of alternative approaches to obtain the best solution for that application, especially if existing designs could be adapted to meet new requirements. This will result in lower overall costs for ammunition, maintenance, and development. It will assure the availability of a responsive industrial base that will have the necessary capacity for mobilization.

One means to achieve commonality would be to limit the technical approach for new systems to one or two of the data links available. For example, all new developments could be limited to consider only inductive and hardwire data links, or only rf and hardwire. However, our review of systems showed that this would greatly limit the flexibility of design, and that each of the four principal data links--rf, inductive, hardwire and optical had distinct advantages for certain applications. In addition, there are other factors which affect harmonization of requirements and systems.

One of the factors which at first appears to reduce harmonization is competition between developers. This can lead to the application of remote-set technologies chosen because the developer has earlier access to planned new system requirements, or serves in an advisory role for other system aspects. Obviously competition tends to lead developers to use their own ideas for a particular application rather than choosing from among viable alternatives. It can result in each developer emphasizing a particular technology only to be different from his competitor.

Other areas where harmonization looked promising were in the use of standard hardware components, data formats, and computer software. We considered the components of the munitions to be set, the launch platform, the data link elements, and the on-board counting and memory modules to determine if greater commonality could be achieved. The possibilities of using common or modular setters were discussed, along with developing a standardized format for the output data that would meet current needs as well as those of future weapon systems. The format would define acceptable data rates, carrier frequencies, number of bits in a digital message and so on. This could then limit the proliferation of new operating characteristics and enhance the possibility of modular approaches.

For applications such as an aircraft stores interface for which several weapons were controlled by the same fire control system, it also seemed feasible to use a standard software interface. This would also apply to systems for which the fire control system differed greatly but the setter and fuze were similar to other applications.

3. SCOPE OF STUDY

A meeting was held 11 January 1977, jointly sponsored by the JFTG and the WPFF. (The minutes of this meeting are given in Appendix A.) Presentations were made by several development labs to describe the status of remote-set work within the three Services. At this meeting the WPFF was tasked to study remote-set fuzing and formed an ad hoc study group with an overall chairman and two sub-committee chairmen. An outline of the task objectives was provided by the JFTG, the sub-committees were assigned responsibilities by weapon categories, and some specific areas of interest were identified as follows.

3.1 Task Outline Assigned by the JFTG

The task objectives assigned to the ad hoc committee were to:

Identify all past and present efforts in remote-set fuzing by technology and weapon category.

Identify in-house and contractual efforts (directed and independent).

Recommend consolidation of programs to avoid duplication or proliferation, if applicable.

Identify issues, justify recommended approaches and obtain tri-Service accord in the remote-set fuzing areas.

Document the foregoing and brief the FMO during the June 1977 time period.

3.2 Definition of Remote Setting

For the purpose of this study, remote setting was considered to be the transfer of data and control signals

from a fire control/setter system over some distance to a munition where the setting unit may be controlled either manually or automatically. The connection from setter to munition is automatic and remote (without operator intervention).

This definition would exclude any hand-set fuze, including the XM587/724 electronic time fuze. The XM587 requires an operator to push the setter against the fuze. However, the General Support Rocket System (GSRS) fuze which is electrically identical to the XM587, is considered remotely set even though it has a permanent hardwire connection between the fuze and setter. Because the XM587/724 must be considered for future artillery systems, it is included in the remote-set fuze analyses.

The study included all identified systems which are seriously contemplated for future development. Aircraft stores management was reviewed since these systems also interface with fuze setting.

4. APPROACH

4.1 Organization

At the 11 January 1977 meeting, Mr. R. Goodman of HDL was selected to chair the ad hoc committee for the study of remote-set fuzing. There were to be two sub-committees. Sub-committee No. 1, chaired by P. Weldon, ARRADCOM, would concentrate on projectiles, free flight rockets, decoys and ground launched missiles. Sub-committee No. 2, chaired by R. Swenson, was to study bombs, mines, torpedoes, air-launched missiles, SLUFAE, SLUMINE, and stores management.

Because of the interlocking responsibilities of the members of the sub-committees, the sub-committee format was dropped and the group met together and acted as a single committee after the first working meeting on 3 and 4 May 1977. In addition to the original appointees, several others participated actively because of their specialized areas of interest. The Air Force representative, R. Erhart of Armament Development Test Center, was unable to attend any meetings of the committee, but sent a letter stating the Air Force view of remote setting for bombs.

The final group was comprised of:

R. Goodman, Chairman
Harry Diamond Laboratories (HDL) Chairman

P. Weldon, Sub-committee Chairman
Armament Readiness and Development Command (ARRADCOM)

R. Swenson, Sub-committee Chairman
Naval Weapons Center/China Lake (NWC/CL)

P. Ward
Naval Surface Weapons Center/White Oak (NSWC/WO)

R. Kaiser
Missile Readiness and Development Command (MIRADCOM)

H. Hagedorn
Armament Readiness and Development Command (ARRADCOM)

R. Sitaramiah
Armament Readiness and Development Command (ARRADCOM)

B. Scheiner
Harry Diamond Laboratories (HDL)

4.2 Establishment of Data Base

Mr. Goodman began the study by conducting a computer data bank search of 1498's, IR&D programs and reports in order to identify past and current efforts to satisfy the task objectives. A copy of the output data is contained in Appendix B.

Subcommittee members were then notified and requested to prepare a summary report of each remote-set fuze program (past, present, future) of which they were cognizant including any which may not have been identified in the data bank because of the selection of key words or because the programs were terminated long ago. These reports were submitted at the 3-4 May 1977 meeting. Copies of the minutes

of the meeting are contained in Appendix C. Each committee member gave a brief technical description of the remote-set fuzing programs in his report. A table was generated compiling remote-set technology areas (iductive, hardwire, rf, acoustic, optical, mechanical, and x-ray) and their respective funding status and potential application to particular weapon systems. Individual committee members were then selected to conduct an analysis and evaluation of all applicable data links for specific weapon applications.

4.3 Analysis

At a second meeting, held 24-25 May 1977 at HDL, the committee member reports were submitted and discussed. An analysis of the various combinations of data links with each weapon system was conducted. This analysis is contained in the following section of this report. From the analysis and discussion at the meeting, the conclusions and recommendations of the ad hoc study group were determined.

5. DESCRIPTION OF SYSTEMS

As was discussed in section 4, the agendas of the two meetings consisted of sorting and organizing the raw data into a format from which comparisons between remote-set (R/S) data links could be made, and then considering the applicability of specific data links to various weapon systems. In this section the details will be given for each weapon system to which a data link has been applied or studied. Discussions of the weapon systems and a comparison of the data links proposed for each weapon system are found at the end of this section. The data generated in these discussions and at the meetings were refined into tables and brief summaries. The tables in this section will give information on the developers of each data link, the status of R/S fuze programs, and which data links have or could be applied to a specific weapon system. In the summaries, the salient characteristics of each R/S data link will be discussed. These characteristics are the basis for the conclusions reached by the study group.

5.1 Remote-Set Program Status

In table 5.1 the agencies responsible for the development and for the primary applications of each type of

TABLE 5.1
REMOTE SET APPLICATIONS

R/S DATA LINK	DEVELOPING AGENCY	
Inductive	HDL	XM443/444 Fuze for 2.75" Rocket
		Fuze/Function Setter for Navy 8" & 5" Guided Projectiles
		Sea Gnat Decoy Rocket
	HDL	Fuze/Function Setter for Navy Gun Systems
Radio Frequency	ARRADCOM	R/S Fuze for Tank Projectiles R/S Fuze for Field Artillery
Hardwire	HDL	General Support Rocket System
	ARRADCOM	M433/M439 Fuzes for 2.75" Rocket
	NWC/CL	Smart Bombs and Missiles
	NSWC/WO	FMU-117 Electric Bomb Fuze
Optical	NWC/CL	Advance Store Communications Technology for Smart Bombs and Missiles
X-ray*	NSWC/WO	Remotely Activated Stores System for Electric Bomb Fuzes
Acoustic*	HDL	2.75" Rocket
		Tank Guns
		Field Artillery

*Not being actively pursued at this time

R/S data link are shown. It can be seen from this table that there is no overlap between agencies in the development of data links except for hardwire. For instance, HDL is the only agency with ongoing programs for inductive links while only ARRADCOM is concerned with RF systems. The Navy inductive link fuze/function setter is an Army/Navy coordinated effort utilizing the HDL inductive approach. Thus, duplication of research effort between agencies on the same data link does not present a problem.

A summary of the program status and FY77 funding level for ongoing R/S fuze programs is shown in table 5.2 and satisfies the second task objective. The first generation 2.75 in. rocket fuzes and several bomb and missile fuzes, all of which use hardwire data links, are type classified. All other R/S fuze systems are in 6.3 with production possible by FY82-84. The risk for all of these fuze programs is relatively low compared to usual 6.2 and 6.3A programs because the technologies are not esoteric, and considerable effort was put into 6.2 development.

5.2 Table of Weapon Systems vs. Applicable Data Link

A matrix was generated of each weapon system and the R/S data link which is either being developed, or has been proposed, or is applicable to that weapon system (see table 5.3). This table is useful to show all the reasonable data link candidates for each type of weapon system. For instance, even though the inductive data link is being funded for ship projectiles, most of the other data links are technically feasible. An important point concerns those cases in which an R/S data link was considered "Applicable" to a weapon, but no previous work had been done which pertained directly to that weapon. In these cases, the most likely data link was selected and engineering judgment used to decide how the data link could best be adapted to the weapon. But, for some of these cases the study group identified serious technical design problems associated with the particular data link for which low-risk solutions could not be determined. The in-depth engineering required to resolve the higher risk solutions was beyond the scope of this study so that when an alternative data link existed which met the technical requirements with a practical approach, that approach was chosen although it might increase the proliferation of data link technology. The characteristics

TABLE 5.2
R/S FUZE PROGRAM SUMMARY

PROGRAM	DEVELOPER	SPONSORING AGENCY	STATUS	FY77 FUNDING (K)
Rockets				
M433/M439	ARRADCOM/ NORTHRUP	2.75" PMO	TC/LP	290
XM443/444	HDL	2.75" PMO	6.3A	120
GSRS	HDL	GSRS PMO	6.3B	250
Sea Gnat	HDL	Naval Research Lab	6.3B	190
Slammer	MIRADCOM		6.2	136
Projectiles				
RF Fuzing System Tanks	ARRADCOM/GE	ARRADCOM	6.3A	211
Fuze/Fn Setter	HDL	NSWC/DL	6.3B	100
Bombs				
FMU-117/B	NSWC/WOL	Pacific Missile Test Center P. Mugu	Production Support	60

TABLE 5.3 WEAPON SYSTEM VS. COMMUNICATION LINK MATRIX

Communication Link	Gun Projectiles: Tank & Self Propelled Guns	Gun Projectiles: Artillery	Gun Projectiles: Shipboard	Rockets: Heli-copter	Rockets: Fixed Wing A/C	Rockets: Gnd to Gnd	Rockets: Decoys	Bombs (Unguided)	Smart Bombs & Missiles
Radio Freq.	6.3A	A	A	P	A	A	A	A	
Inductive	A	A	6.3B	6.3A	A	A	6.3B		
Hardwire		6.4	A	TCLP	A	6.3*		TC	TC
Optical			P	A	A				P
X-Ray								P	
Acoustic	A	A	A	P					
Mechanical			TC						

P - Proposed: Competing system proposed for use but not now funded
A - Applicable: Not proposed for this particular weapon but could reasonably be considered

*GSRS in 6.3A Slammer in 6.2

stated in section 5.3 are inherent to the data link and not limited by the specifications of a particular application.

5.3 Data Link Applications

The data links can be classified by general characteristics such as data rate, additional fuze cost, and reliability, as shown in table 5.4 Some of these categories are subjective to some degree, and may depend on the requirements of the system using the R/S data link. However, these characteristics were agreed to after discussion during the committee meeting. This section highlights the salient characteristics of each data link.

5.3.1 Radio Frequency

The data link is being developed for a family of tank munitions which include the Beehive Flechette and a developmental high explosive multi-purpose (HEMP) round. The components of the system include a solid-state transmitter and externally (to the tank) mounted stripline antenna. Information from the fire control computer is coded and pulse modulates the X or Ku band carrier. A receiver circuit in the fuze receives, detects and stores the digital data which is transmitted by the rf data link. The data must be received during the window between the projectile exit from the muzzle and the exit of the ionized fireball which acts as a shield to the carrier. These characteristics of the system change little when applied to other weapons. The primary advantage of the link is that the most recent information can be sent to the fuze just after firing of the munition. In a tank, a round is held in the chamber until a target is sighted and the gun fired. The information transmitted to the fuze through the link will then be the latest available to the fire control system. A second advantage is that no modification is required to the gun since an antenna can be mounted on some appropriate part of the weapon platform. A disadvantage of the data link is that it might be difficult to use in a situation where high power radars are normally present, such as aboard ship. Possible saturation of the receiver circuit in the fuze by a radar signal with a similar frequency might make the system unreliable.

TABLE 5.4

	Hardwire	Ind	RF	Optical	X-Ray	Acoustic
Setter Cost[1]	Low	Low	Low	Low	Low	Low
Additional Cost[2] to Fuze	Low	Low	Low	Low	High	Low
Setter Reliability	High	High	High	High	High	High
Reliability of Link	Fairly*	High	High	High	High	High
Energy Transfer to Fuze	High	Low	None	Very Low	None	Low
Reverse Link Capability	Yes	Yes	No	No	No	No
EMI Susceptibility	Low	Low	Fair-ly Low	Low**	Low	Low
Generated Signature	No	No	Small	No	Small	No
Data Transfer[3] Speed	Medium	Med.	High	High	Medium	Low

[1]Low < $ 3,000 Installed
High > $10,000 Installed

[2]Low < $ 5
Medium $ 5 - 10

[3]Low < 1 kHz
Medium 1 kHz - 5MHz
High 5 MHz - 50 MHz

*Concern over connector reliability
**Problem with use in high field intensity environment

5.3.2 Inductive

Several inductive systems have been developed for weapons with dissimilar requirements, including the 2.75-in. fixed-fin aerial rocket (FFAR), the Navy 5-in. guided projectile, and the Navy Sea Gnat decoy rocket. The data link operates as a loosely coupled transformer, where the transmitter (or primary) generates an ac inductive field which is detected by the receiver (or secondary). A reverse data link is implemented by shorting the receiver coil thereby changing slightly the impedance reflected back to the transmitter. These systems differ mainly in the mechanical configuration of the coils, and the format of the amplitude modulated data. A system similar to the XM443/XM444 rocket fuzes was assumed for the tank projectile, fixed wing A/C rockets, and ground to ground rocket applications. Inductive data links are useful because of their versatility. The positive features of an inductive data link are that it can transmit energy for setting and memory, incorporate a feedback link to verify data, have little susceptibility to EMI, and does not generate a detectable signature. However, a coil of wire is required to transmit the inductive signal, and this coil must be located in close proximity to the fuze. Unless the weapon has been designed to specifically utilize inductive remote setting, some type of retrofit will be necessary. For instance, it is technically feasible to modify the breech of a tank cannon to accept a transmitter coil, but the cost may be prohibitive. The data rate of an inductive link may be limited to 100 kHz, which could limit its applicability in sophisticated, high data rate communication links.

5.3.3 Hardwire

The M433/M439 (product improved) rocket system would be a logical choice for a hardwire data link to fixed wing A/C rockets, and the Slammer ground to ground rocket if it were produced for the helicopter role. The XM587 time fuze has been suggested for ship projectiles because of its data verification feature. When the fuze or the guidance and control section of a weapon requires high power prior to launch, a hardwire connection must be made in any case, so that information to the fuze can be sent via the power cable or another wire on the same connector. It is probably the least expensive data link because sophisticated transmitter and receiver circuits are not required.

One disadvantage of hardwire links is that in situations where connection must be made in the field, as for Navy aircraft, it has been found that reliability is greatly reduced. Navy experience in the field has shown that human error, poor mechanical contacts, and high stress environments tend to lower the reliability of hardwire data links. A second disadvantage is that hardwire connections are not suitable for rapid fire weapons where sliding contacts would have to be used, rather than fixed connectors. Data rates can be fairly high, but there is some noise susceptibility due to the interconnecting wires.

5.3.4 Optical

An optical data link was proposed for shipboard projectiles. Another was proposed for aircraft rockets based on the Advanced Stores Communication Technology (ASCT) system. The ASCT system could be used with either a connector termination for the fiber optics, or no termination if the weapon can be optically aligned with the light output. The transmitters would be high intensity LED's while photodetectors act as receivers. The primary advantage of an optical data link (assuming in this case fiber optic technology) is its high rate of data transfer. This would be especially useful in conjunction with digital processing systems on aircraft which would communicate by means of multiplexed data busses. Other advantages over hardwire include weight savings, price savings (in the future), and no EMI problems. Disadvantages of the system are that an optical data link without a connector would be difficult to align, and energy transfer is very limited in a practical system.

5.3.5 X-Ray

The Remotely Activated Stores System (RASS) is an x-ray data link which was developed for setting electronic bomb fuzes dropped from fixed wing aircraft. It has the capability of setting bombs dropped from any wing station using a single transmitter on each aircraft. It is also not susceptible to electromagnetic interference (EMI) and does not provide a readily detectable signature. Further development of this link is limited by the solid state detector material which is presently developmental and expensive.

5.3.6 Acoustic

An acoustic vibration system was developed in the early 1970's by both ARRADCOM and HDL, but dropped in favor of other approaches. The system transmitter was an ultrasonic welder, modified to allow amplitude modulation of the 60 kHz carrier. The main problem of the system is that data transfer is slowed by the ringdown time of the metal structure containing the fuze. In addition, it was found during development that commercial transducers suitable for receiving the ultrasonic signal were not available and that there were no development efforts in that area.

5.4 Detailed Technical Descriptions

Each fuze for which a remote set capability is presently being investigated has been described (Appendix D) in some detail by the developer. These descriptions contain information on the primary data link approach for that weapon and the advantages and disadvantages of some of the alternate approaches in table 5.4. The aircraft stores management system being considered by NWC/CL is also described in this appendix. As far as the Air Force is concerned, Mr. Erhart's letter (Appendix E) indicates the Air Force is not currently pursuing any specific basic remote-set technology efforts; however, under a Memorandum of Agreement AFATL and NWC are planning to utilize a common stores management system if and when the Air Force adopts remote-set fuzing.

6. RESULTS

From the data presented in section 5, a set of conclusions were developed based on analysis, engineering judgment and debate. The results are detailed in Appendix D, but will be summarized in this section. As was stated in section 5.2, the results are often based on the characteristics of data links which are "Applicable" to a weapon but for which no previous work had been done pertaining directly to that weapon. The x-ray and acoustic data links will not be discussed since basic technical problems have not been solved. However, these links may, after future development, be suitable for application to some of the weapons.

6.1 Tank Guns

For tanks the forcing requirement is that a round must be loaded in the gun for quick reaction against personnel equipped with anti-tank missiles or helicopters. If the round chosen requires a settable fuze, then a suitable data link must be capable of setting the round either immediately before it is fired or soon after it exits the muzzle. In addition, any significant modification of the breech mechanism may be unacceptable, and other modifications to the tank should be minimized. Another consideration is that where a high volume requirement exists for the remotely settable ammunition, the cost of the remote-set electronics should be as low as possible. The rf data link has been developed primarily for the tank gun application and meets the requirements stated above. It also may be modified to measure the muzzle velocity, and has the capability of correcting for velocity variations which would cause range errors. A potential disadvantage of the rf link is that a detectable rf signature will be generated. However, the results of a study funded by ARRADCOM shows that this effect is unlikely to cause problems in the tank application.

The use of an inductive data link for tank rounds would present several mechanical design problems if there is a requirement to set the round after it has been loaded or fired. Unless the breech could be modified it would be necessary to mount the coil at the gun muzzle. In order to ensure survivability, structural problems would probably be encountered in the mechanical design of the coil and also in the flexible cable which would transmit the signal from the fire control system to the coil. Although there is no theoretical reason that data could not be transmitted fast enough to set the fuze after firing, a system with a sufficiently high data rate has not been demonstrated. In addition, a means of measuring muzzle velocity prior to muzzle exit would have to be utilized in order to adjust the data for transmission to the inductive link.

An optical data link would share the advantages of small size, fast data rate, and no modifications to the gun with the rf link. However, the problem of transmitting a detectable optical signal to the round after it exits the muzzle has not been explored.

Based on the above discussion, the rf data link offers superior performance for the tank gun application at this time.

6.2 Artillery

Requirements for artillery gun systems are undergoing change to adapt to changing battlefield conditions. The implementation of the TACFIRE/BCS system in 1982 will make the gun the slowest element in the artillery system. This can be overcome in part by utilizing automatic data communication which would allow the latest information from TACFIRE/BCS to be transmitted quickly to the entire gun battery with the additional benefit of eliminating the error-prone human interface.

Since there is no firm requirement as yet to remotely set artillery projectiles, specific characteristics of future systems are not known. However, since the equipment presently required to set time fuzes is minimal (either a special wrench or in the future an XM587 setter), any increase in the amount or complexity of equipment used with a remote-set link would be undesirable. It would be highly desirable to decrease the complexity of the fuze setting operation while retaining high accuracy, safety, and reliability, to obtain the highest achievable firing rate.

The inductive, rf, and hardwire remote-set systems all have the potential to fulfill these requirements as described in the next sections.

6.2.1 Inductive

In appendix D, the applicability of the Navy Remote-Set Inductive Fuze System to tank and artillery projectiles is discussed in some detail. The technical risk involved in adapting the inductive link being developed for the Navy 5" and 8" guns to Army artillery would be low. However, if the inductive setter was integrated with the weapon, additional equipment would be required for the inductive link, including a transmitter coil and perhaps a fixture to hold the shell while the fuze is being set. Alternatively, a setter similar to the XM36E1 setter for the XM587/724 fuze could be used. A careful study of Army requirements and Navy development schedules would be necessary to ascertain

the potential monetary savings realizable by reducing the development costs of any Army remote-set fuze, and be increasing the commonality between Army and Navy time fuzes. Such a study could lead to a Joint Service Operational Requirement (JSOR).

A hardwire remote-set link, the XM587, is presently in the ED phase and should go into production in the near future. The hand held XM36E1 setter, which is used to set the XM587 fuze, has a data verification capability and can be interfaced with the TACFIRE/BCS system. A disadvantage to this setting procedure is that mechanical contact must be made between the setter and fuze.

6.2.2 RF

The rf link developed for tank guns is a contender for the artillery application. The features of the rf link include: no modification to the gun as only a small rugged transmitter antenna must be located to illuminate the muzzle region; no special crew procedure, such as hand setting, is required; and dopper radar can be used to measure the muzzle velocity so that corrections to the time setting can be applied to increase system accuracy.

6.3 Shipboard Guns

At present, remote setting of projectile fuzes on ships is accomplished mechanically. However, the Semi-Active Laser Guided Projectile (SALGP) requires at least 24 bits of data, and these must be set electronically. The primary requirements for a shipboard data link are that it have a data verification capability, the ability to operate in the shipboard EMI and mechanical environment, and be compatible with the present mechanical setter. Data verification is necessary so that if a SALGP cannot be set, another round could be fired immediately after the first. Ordinarily another round would not be fired until the forward observer evaluated the results of the first round. The inductive data link was selected for further development since it alone meets all of the requirements stated above. Data links originally considered applicable to the setting of shipboard projectiles include optical, hardwire, and rf; but these were rejected based on the following arguments.

The rf data link has three major drawbacks: First, the high energy fields generated by shipboard radars could saturate the receiver on the projectile unless a fairly sophisticated design was utilized; second, the rf link does not have a data verification capability; and third the ionization cloud generated by Navy guns may preclude reliable communication.

Also considered was the optical projectile fuze communication link then under exploratory development at NSWC/WO. Although the optical link was technically feasible, a suitable location for the optical sensors on the guided projectile body could not be established. The optical link does not have a data verification capability, and its cost was projected to be greater than the cost of an inductively set fuze.

A hardwire data link has been proposed for utilization in Naval gun systems. The XM587/XM724 fuze, set with the XM36E1 fuze setter, is an electronic time fuze presently in Engineering Development (6.4) at HDL, and would be used on HE and Improved Conventional Munition rounds. The advantages to the Navy of using the XM587/XM724 fuze include elimination of the bulk of development costs, and commonality with an anticipated high production rate Army fuze. Some disadvantages of using the XM587/XM724 fuze system for Navy Guns are that Naval gun systems would be equipped with three separate fuze setters--mechanical for inventory fuzes, inductive for the SALGP round, and the XM36E1 for the time fuze; the time required by the XM36E1 to set a fuze for maximum flight time is longer than the time available for setting in the 76 mm and 5"/54 gun mounts when fired at maximum rate; and the potential for corrosion of both the setter and the fuze contacts may be significant in the salt air environment.

In summary, the inductive data link was selected to set the SALGP and the ICM rounds since it meets all of the requirements of the Navy 5" and 8" gun systems. Other data links could, with further development, meet the same requirements, but would be more costly to implement than the inductive link. In addition, the inductive link has the growth potential to be applied to other Navy guns systems such as the 76 mm MK75.

6.4 Aircraft Rockets

The primary application for aircraft rockets is the 2.75" FFAR used as an area weapon on helicopters. Although fixed wing aircraft have used 2.75" and 5" rockets in the past, changing tactics have, for the most part, eliminated the use of rockets on high performance A/C. Should remotely settable rockets be used on fixed wing A/C, a system similar to the helicopter version could be adapted. Remote set requirements for helicopters are very flexible. The set time must be less than the minimum ripple interval of 60 ms, since time data must be updated as the rockets are fired. A back-up mode is desired so that the munitions can be used, although with some limitations, when the setter is inoperable. Data verification is not required for this application. The XM433/XM439 Fuze System which utilizes a hardwire link has been type classified for limited production; the XM443/XM444/XM41 Improved Remote-Set Fuze System is in Advanced Development; and an RF data link similar to the system developed for tank projectiles has been proposed.

The hardwire data link has several minor drawbacks. First, the accuracy of the time fuze degrades when the firing range is greater than 4500 m, and its growth potential beyond 6000 m is limited. Second, there is no back-up mode if the setter is not operating since power is derived from the setter. (These are, of course, drawbacks of the fuze, not the data link.) Third, reusable mechanical connector contacts could degrade performance in the field, although no such problems were experienced during DT II/OT II field tests.

The data link, developed by ARRADCOM, was in competition with the HDL developed inductive system for use in the 2.75" FFAR. The HDL system was chosen, although both systems meet the data transfer speed, reliability, and back-up mode requirements. The inductive link has the disadvantage of requiring a modification to launchers in the inventory so that the transmitter coil can be retrofitted. The transmitter coil can be manufactured integrally with the light weight launcher presently under development. The rf data link has the minor disadvantage of generating a short rf signature, and the possibility of crosstalk between helicopters must be considered. Also, the helicopter must be modified in order to mount the transmitting antennas.

An optical system for helicopter rockets would have to overcome the problem of supplying power to the fuze electronics before the rocket is launched. Also, the lack of orientation of the rocket in the launcher could be a significant problem in aligning the transmitter and receiver. An optical data link is not being developed for the helicopter application at this time.

In summary, the inductive link is a leading candidate for a second generation remote-set rocket fuze system and was chosen to go into Advanced Development.

6.5 Ground to Ground Rockets

Two rocket systems are presently under development for the ground to ground application. The GSRS incorporates 8" free flight rockets in a six round disposable launcher pod. Two of these pods, which also serve as shipping containers, are mounted on a self-propelled tracked vehicle. The principal warhead will consist of dual-purpose submunitions, and a time fuze will be used for dispersal of the sub-munitions at the proper altitude. The system is intended to support cannon artillery under surge conditions. The Slammer VI although still in the conceptual stage, is intended to provide high rates of firepower to advance units. It consists of six standard 19-tube launchers (114 total tubes) mounted on a M91 Chemical Rocket Launcher and firing 2.75" FFAR's.

The requirements for the GSRS were essentially fixed by schedule considerations. A hardwire data link connecting the fire control/setter to the XM587 fuze electronics was selected because the design had been proven in ED testing on artillery projectiles. Features of the GSRS electronics package include a nonvolatile memory, data verification, and "fail long" failure modes to enhance overhead safety.

The Slammer VI system would probably utilize the XM443/XM439 hardwire setting system initially. When the XM443/XM444 inductively set system is fielded for use on helicopters, it would probably also be phased into the Slammer VI launchers.

6.6 Decoy Rockets

HDL is presently engaged in the design of an inductive remote-set fuze for the Navy Sea Gnat decoy rocket. The Sea Gnat is a 5" rocket operating at short range with a decoy warhead. The Navy uses an inductively coupled squib ignition circuit to prevent EMI problems. The advantages of an inductive data link for this application are that no connection is needed after reloading, and the EMI protection for the squib ignition circuit is not compromised.

6.7 Unguided Bombs

Selection of one of four bomb fuze options--either proximity, impact, long delay, or short delay is made by supplying one of four voltages to the fuze. The selected voltage is available on the end of a phone jack type connector, but is insulated from the bomb fuze until after the bomb fuze is released. When the bomb is released, the powered end of the connector slides up and makes contact with the fuze for a length of time sufficient to charge a capacitor to the proper voltage. The primary requirement for bomb fuzes is that no power be applied to the fuze before the bomb physically leaves the rack. Changing this system would be worthwhile only if either a bomb fuze with additional capabilities (such as selectable delay-after-impact) was developed, or if a data link more reliable than hardwire contacts was desired.

An rf link would have the major disadvantage of being required to operate in a very high EMI and RFI environment. Also, the addition of a possible rf signature source is undesirable. One technical problem is that there would be no power available so that a power source would have to be developed. The use of an inductive link would depend on finding a suitable location for the transmitter coil. Assuming that only the remote-set electronics in the fuze were powered, but not firing capacitors, the data message could be sent before the bomb left the rack. If this were not permitted, then the electronics would have to be powered and the message sent while the bomb was within 1-2 feet of the transmitter coil.

There are, at present, no plans to change data links from the hardwire type.

6.8 Smart Bombs and Guided Projectiles

All smart bombs and guided projectiles require significant amounts of prelaunch power in order to spin gyro-stabilizers or cool down IR detectors. This means that some type of hardwire connection must be made between the aircraft and the munition. In addition to the power input, other inputs must be provided for prelaunch checkout and to supply guidance information. Since a connector must be provided to supply power to the weapon, this connector would also contain the contacts which supply data to the weapon. These data exchange contacts could be either hardwire or optical. In either case, it is envisioned that future armament systems will be digital using either a distributed or centralized processing architecture and multi-plexed data busses. An electro-optic communication system using fiber-optic cables would have many advantages over a hardwire cable. Compared to hardwire cables, the fiber-optic cable can provide higher bandwidth, more EMI resistance, less cross-talk between lines, and no sparking danger when broken. Its drawback at present is in repairability, since repairs must be accomplished by precision tools.

7. CONCLUSIONS

The most important conclusion reached by the committee as a result of this study is that there is presently little or no duplication of effort within the various technology areas. Parallel approaches are being pursued but this is necessary and justifiable at the early stages of development to provide alternate approaches to meet specific requirements.

No single technical approach provides a satisfactory solution to all of the applications so that consolidation of programs to avoid duplication is not advisable. As discussed in Section 5, each system has limitations which preclude its use for a specific program. And, in fact, as each application was reviewed, it was observed that the most appropriate solution for remote setting, considering the specific system constraints, is being developed for on-going efforts. As a result, there is no unnecessary duplication although different approaches are being developed for different systems.

In Section 2 it is stated that competition could prevent maximum harmonization. However, competition is vital

to meet long term needs in order to maintain and develop alternate technologies through and including program element 6.3A. Competition is necessary to prevent technical stagnation and technical obsolescence and enables the best choice to be made for future requirements. But, it is essential that the competition be managed to prevent unnecessary overlap and duplication while still allowing freedom to the designers.

A major consideration in achieving commonality is the use of a common setter for several systems. However, this study concluded that one setter cannot perform satisfactorily for all remote-set systems. Even in limited cases a common setter cannot be used because of the different weapon systems interfaces and requirements. In many cases the setter functions are integrated with the complex fire control computer, as in the GSRS vehicle or the helicopters which fire 2.75-in. rockets. For example the fuzes and launchers for helicopter rockets and for Slammer VI would be identical. However, in one case the setter is integrated and in the other case the setter must be a stand-alone piece of equipment, perhaps operated by internal battery power.

Throughout the study it was apparent that the weapon system was the driving factor in all design decisions. Care should be exercised that the attempt to achieve commonality of remote-set systems will not impose a design constraint that will result in increased overall cost or lowered military effectiveness. Any small increase in development cost and/or risk which accrues to the program by choosing an approach for remote setting different from a more advanced design is insignificant compared to the benefits of increased cost effectiveness which results from choosing a better design. In most cases the design phase of a conventional fuze development program is a small part of the cost. The major cost is in the procurement of test items, conducting tests, and engineering support and documentation after the design phase. Little if any, cost savings result from forcing a common or existing design into a new system. However, there can be payoff in lowering development risk and there is clearly a benefit in choosing a design similar to a current approach utilizing common items if possible. This lowers technical risk and allows the existing mobilization base to be readily adapted to the new system.

8. RECOMMENDATIONS

Specifically, the ad hoc study group makes the following recommendations to enhance the development and utilization of remote-set systems.

a. It is recommended that no changes be made in data links proposed for systems which are presently in Advanced Development. It is the committee's opinion that the selection of the remote-set data links for use in these on-going programs was based on sound technical considerations (discussed in Sec. 5). Also, a single common remote-set data link does not appear technically feasible at this time. Future technical developments may very well allow one data link to be used for all new weapon systems. However, until a single data link is developed which can meet the diverse technical requirements of all weapon systems, multiple approaches must be taken and the recommendations below are made assuming a multiple approach philosophy for new weapon systems.

b. Draft requirement documents for remotely set munitions should be distributed by the tri-Service fuzing points-of-contact to their respective fuze development groups for review so that the best approach can be proposed and the greatest possible harmonization be achieved.

c. Where two or more remote-set systems appear equally applicable and the choice is not clear because of unknowns which will not be resolved until later in the development program, then alternate competitive approaches should be funded at least through program element 6.3B. This will assure that the most cost-effective approach is available as the system unknowns are resolved.

d. R&D programs which have promise for future remote-set applications should be funded to support continued progress. This is important because weapon systems possess physical and electrical design constraints which may preclude the use of current technology. Such things as data rate for rapid fire, or the need for operation in extreme EMI environments may preclude the use of existing mature developmental approaches for some new systems.

e. An attempt should be made to standardize the data link format between the fire control computer and

the setter. This could be done, for example, by using the MIL-STD-1553A data buss for computer interfaces. It is not practical to also standardize the interface between setter and fuze because of the wide variation in designs.

f. Continued close coordination between developers in the three Services must be maintained. Periodic discussions are necessary to obtain maximum harmonization. This could be done through the WPFF or a similar but separate Remote-Set Committee.

g. As stated in Sec. 6.3, the Navy is currently developing an inductive remote-set fuze for the 5" and 8" guided projectiles and for the 8" ballistic projectile. The Army currently has no definite plans for remote-set field artillery but for the sake of future commonality and inter-operability, it is recommended that the Army determine if a need for remote-set artillery fuzing will exist. If there will be a need, then the Army requirements should be determined and a JSOR prepared to insure commonality.

h. Finally, to be assured of obtaining a smooth running committee able to dedicate sufficient time and effort to a study of this type, it would be highly desirable for the JFTG to prepare a written request for each agency, requesting support, naming the individual required, generally outlining purpose and scope of the committee, and then estimating duration, funds and travel required.

APPENDIX A

DEPARTMENT OF THE ARMY
HQ US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND
JOINT FUZE TASK GROUP
2800 POWDER MILL ROAD. ADELPHI. MD 20783

DRCDE-JFTG 24 Jan 77

MEMORANDUM FOR RECORD

SUBJECT: Minutes of a Joint JFTG & JTCG/MD/WPFF Meeting on Remote-Set Fuzing -- 11 Jan 77

1. A joint meeting on Remote-Set Fuzing was held at the Harry Diamond Laboratories, Adelphi, MD on 11 Jan 1977. Attendees are listed in enclosure 1.

2. COL P. G. Burbules, JFTG Chairman, opened the meeting by reviewing the JFTG tasks. He emphasized task No. 4, dealing with joint harmonization, of which the remote-set fuzing study is a sub-task.

3. He also reviewed the JFTG Charter, wherein it is planned to transition the JFTG functions to the JTCG/MD/WPFF at some time in the future.

4. He stated that he requested the remote-set fuzing study be conducted by the Working Party for Fuzes (Incl 2) in order that they become familiar with methods and procedures used by the JFTG to conduct their business.

5. He reiterated that the task would be under full control of the WPFF, including the authority vested in the JFTG for this task. The JFTG would support them as may be required. He requested that the WPFF study group brief the JFTG, informally on a monthly basis, but plan a formal briefing in approximately three months.

6. Mr. Vrataric, JFTG, acted as a temporary meeting Chairman and proceeded to call for briefings by the Service Representatives.

7. These briefings consisted of descriptions of remote-set activities being pursued by the individual agencies. The briefers were:

R. Goodman, HDL
R. Swenson, NWC
L. Horowitz, PA
D. Wasmund, NSWC

The briefing materials will be included in a report at a later date.

8. Mr. Horowitz identified several programs on remote-set fuzing being pursued under contract by Project Managers for helicopters. These programs are basically the hardwire approach and stores-management used in some of the present helicopters.

9. Mr. Sid Englander, Chairman of the WPFF, took over Chairmanship of the meeting and stated that the WPFF was delighted that the JFTG requested them to conduct the study. He accepted the task on behalf of the WPFF.

10. The group then proceeded to list all remote-set activities, by weapon class and participating agency. The listing revealed two groups of weapon categories that could be described as having some common features or participating agencies, that would require two Ad Hoc committees.

11. Mr. R. Goodman, HDL, was appointed Chairman of the overall task. His selection was based on the fact that he supervised several Army and Navy remote-set fuzing programs, thus was well-versed in the field.

12. Two subcommittees were established as follows:

<u>Committee No. 1</u>

P. Weldon, PA, Chairman
J. Young, NSWC
R. Goodman, HDL
J. Winning, MICOM

This group would serve as committee members or as contacts to obtain working members for their respective agencies. They would concentrate on:

Projectiles, guided and unguided
Rockets, ground and air-launched
Decoys
Missiles, ground launched

<u>Committee No. 2</u>

R. Swenson, NWC, Chairman
P. Ward, NSWC
R. Goodman, HDL
J. Winning, MICOM
R. Erhart, ADTC
M. Baran, PA/AUSCOM

They would concentrate on:

Bombs
Mines
Torpedoes
Missiles, air-launched
Mines, SLU-FAE, SLU-MINE
Stores management

13. Mr. Goodman stated he would contact all persons named and meet with them to begin the study. It was agreed that the Task Outline, included as enclosure 3, would be used as a guide.

14. There appeared to be a consensus that some of the efforts may involve similar or parallel approaches and that some commonality may be achievable.

15. Mr. Vrataric, JFTG, would continue to be the point of contact for the study group and would provide advance summary data sheets being submitted by the Services.

3 Incl
as

FRANK VRATARIC
Program Analyst, JFTG

DRCDE-JFTG 24 Jan 77

SUBJECT: Minutes of Joint JFTG & JTCG/MD/WPFF Meeting on Remote-Set Fuzing -- 11 Jan 77

DISTRIBUTION:

Cdr, USA Missile Command, ATTN: DRCPM/Mr. Kaiser, Huntsville, AL 35809

Cdr, PA, ATTN: SARPA-AD-F/Mr. Horowitz, Dover, NJ 07801

Cdr, PA, ATTN: P. Weldon, Dover, NJ 07801

Cdr, USA Missile Command, ATTN: DRSMI-DC/Mr. J. Winning, Huntsville, AL 34809

Cdr, PA, ATTN: M. Baran, Dover, NJ 07801

Cdr, HDL, ATTN: DRXDO-DAD/Mr. Finger, 2800 Powder Mill Rd., Adelphi, MD 20783

Cdr, HDL, ATTN: DRXDO-DAD/Mr. Goodman, 2800 Powder Mill Rd., Adelphi, MD 20783

Cdr, HDL, ATTN: DRXDO-PP/Mr. Neily, 2800 Powder Mill Rd., Adelphi, MD 20783

NAVAIR, ATTN: Code AIR 53247/Mr. Englander, Wash DC 20361

Cdr, NWC, ATTN: Mr. Swenson, China Lake, CA 93555

Cdr, NSWC, ATTN: Mr. Wasmund, Silver Spring MD 20910

Cdr, NSWC, ATTN: Mr. Eby, Silver Spring, MD 20910

Cdr, NSWC, ATTN: Mr. Young, Silver Spring, MD 20910

Cdr, ATTN: AFATL-DLJF/Mr. Erhart, Eglin AFB, FL 32542

JFTG Staff

REMOTE SET FUZE MEETING

11 Jan 1977

ATTENDEES:

NAME	ORGANIZATION	PHONE NO.
Erhart, R.C.	ADTC/DLJF	AV 872-2223
Englander, Sid	NAVAIR/AIR	AV 222-3848
Swenson, R.M., Code 3353	Naval Weapons Center	(714) 939-7323
		AV 245-7323
Kaiser, Dick	DRCPM-RK, MICOM	746-3201
Finger, Dan	HDL	AV 290-2441
Williams, J.R. MAJ USAF	JFTG	AV 290-2812
Higuera, R.L.	JFTG	AV 290-2812
Goodman, R.S.	HDL	AV 290-2440
Neily, Darrell	HDL	AV 290-2755
Wasmund, David	NSWC/WOL	394-2156
Eby, R.E.	NSWC/WOL	394-1663
		AV 290-1663
Vrataric, F.	JFTG	AV290-2812
Horowitz, Leo	Picatinny Arsenal	880-6358
Burbules, P. COL	JFTG	394-2814
Weldon, P.	ARRADCOM, DRDAR-LCF-T	880-2442

DEPARTMENT OF THE ARMY
HQ US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND
JOINT FUZE TASK GROUP
2800 POWDER MILL ROAD, ADELPHI, MD 20783

DRCDE-JFTG 21 Dec 76

SUBJECT: Remote Set Fuzing Study

Commander
Air Force Systems Command
ATTN: SDZ/Mr. Hartmeyer
Andrews AFB, Wash DC 20334

1. The Fuze Management Organization (FMO) Charter (Incl 1) identifies the Joint Technical Coordination Group (Munitions Development) Working Party for Fuzes (JTCG/MD/WPFF) as the successor organization to the Joint Fuze Task Group (JFTG) (Section IV). Section V states "The JFTG will plan the transfer of the continuity of its operation to the JTCG/MD/WPFF."

2. To facilitate such a transfer, the WPFF should have prior experience in using the techniques of the JFTG for obtaining tri-Service accord on difficult problems, or presenting clearly defined issues, with alternative courses of action and recommendations, to the Fuze Management Board (FMB) for decision. For this reason, it is requested that the JTCG/MD/WPFF undertake the task of harmonizing current Remote Set Fuzing parallel approaches. A task outline is attached (Incl 2). A preliminary meeting date has been scheduled for 11 Jan 77, but it may be rescheduled if necessary. A tentative agenda is attached as inclosure 3.

3. The JFTG will provide overview guidance and assistance as required. The JFTG point of contact is Mr. Frank Vrataric, phone number 394-2812.

~~3~~ Incl
as

PETER G. BURBULES
COL, USA
Chairman, JFTG

INCL 2

TASK OUTLINE ON REMOTE SET FUZING

1. INTRODUCTION:

The Joint Fuze Task Group (JFTG) is undertaking several studies dealing with fuze proliferation and duplication of effort within the Services. JFTG responsibilities will be transferred to the JTCG/MD/WPFF when all assigned tasks are completed, or require only continuing maintenance.

2. REMOTE SET FUZING:

Several remote set fuzing investigations are being conducted by Army and Navy agencies. Technical approaches include direct contact, inductive, optical, acoustic, x-ray, and RF. Applications include bomb, rocket and artillery weapon systems. These efforts may lead toward development of two (or more) remote set fuzes for similar applications, i.e., proliferation and lack of commonality. Insofar as possible, technologies and Service tasks should be targeted to meet multi-Service requirements with a single fuze.

3. RESPONSIBILITY:

The Chairman, JTCG/MD/WPFF is assigned the responsibility to conduct the remote set task to meet the objectives specified herein.

4. OBJECTIVES:

Specific tasks objectives are:

a. Identify past, present, and future efforts in basic remote set technology.

b. Identify past, present, and future efforts directed to a specific weapon system.

c. Identify in-house and contractural efforts of (a) and (b) above.

d. Cite requirements and present application along with future development plans and applications.

e. Establish/recommend schedules (or modifications to existing schedules) for identifying approaches which would satisfy multi-Service needs.

f. Establish/recommend any additional efforts that may be required to extend one Service's technical efforts to satisfy specific requirements of other Services.

g. Provide estimates of costs for fuzes, ancillary equipment (remote set), production equipment, etc., for recommended approach(es).

h. Obtain Tri-Service accord on approaches for multi-Service application. If such accord cannot be reached, even though the JTCG/MD/WPFF is of the opinion that such accord is feasible and attainable in the interest of commonality, then:

(1) The JTCG/MD/WPFF shall clearly define the issues and alternative courses of action.

(2) Prepare a recommended course of action.

(3) Present (1) and (2) above, by formal briefing, to the FMB for decision.

i. Justify multiple approaches. If in the opinion of the JTCG/MD/WPFF that a single approach is not feasible or desirable, then:

(a) Prepare a detailed justification for multiple approaches.

(b) Identify resulting proliferation.

(c) Identify potential commonality, e.g., single coding approach, etc.

(d) Present (a), (b) and (c) above, by formal briefing, to the FMB for approval.

j. Task the JFTG Ad Hoc user panel to prepare and staff a JSOR by weapon category, if applicable.

5. SCHEDULE:

The foregoing studies should be completed by Jun 77 in order to impact the FY78 budget. A preliminary meeting has been scheduled for 0900, 11 Jan 77 at the Harry Diamond

Laboratories, Room 2G014. Participants should be prepared to brief on their respective efforts as well as submit written summaries for inclusion in the minutes.

6. AUTHORITY:

The full authority of the JFTG, to the extent provided in the FMO Charter, is hereby delegated to the Chairman, JTCG/MD/WPFF for requesting Ad Hoc support in the conduct of this task.

APPROVED:

PETER G. BURBULES
COL, USA
Chairman, JFTG
18 Dec 76

APPENDIX B

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DDC DATA BASE: TECHNICAL REPORTS

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--                                  ******************
--20 - REPORT CLASSIFICATION:        CONFIDENTIAL
--                                  ******************
-- 1 -  AD NUMBER: C005874L
-- 6 -  UNCLASSIFIED TITLE:         SELECTIVE EFFECTS
--      ARMAMENT SUBSYSTEM (SEAS) COST AND OPERATIONAL
--      EFFECTIVENESS ANALYSIS (COEA). VOLUME I. PART I.
--      EXECUTIVE SUMMARY.
--******
-- 1 -  AD NUMBER: B008947L
-- 6 -  UNCLASSIFIED TITLE:         STUDY OF LIGHTWEIGHT
--      ALTERNATIVES TO THE XM132 REMOTE SET SUBSYSTEM.
--******
-- 1 -  AD NUMBER: B007875L
-- 6 -  UNCLASSIFIED TITLE:         DEVELOPMENT TEST II

--      (ENGINEERING PHASE) OF IMPROVED 2.75-INCH ROCKET
--      SYSTEM (XM433E1 FUZE).
--******
-- 1 -  AD NUMBER: B002668L
-- 6 -  UNCLASSIFIED TITLE:         DEVELOPMENT TEST II
--      (ENGINEERING PHASE) OF IMPROVED 2.75-INCH ROCKET
--      SYSTEM.
--******
-- 1 -  AD NUMBER: B002065L
-- 6 -  UNCLASSIFIED TITLE:         REMOTE SETTABLE FUZE
--      COMMUNICATION LINK SYSTEM (TALKING FUZE).
--******
-- 1 -  AD NUMBER: A031302
-- 6 -  UNCLASSIFIED TITLE:         INVESTIGATION OF LONG-
--      TERM STORAGE AND REVERSE LINK METHODS FOR THE 5-

--      INCH SALGP DATA LINK.
--******
-- 1 -  AD NUMBER: A014891
-- 6 -  UNCLASSIFIED TITLE:         ANALYTICAL INVESTIGATION
--      OF INDUCTIVE LOOP COUPLING FOR REMOTE SET FUZING.
--******
-- 1 -  AD NUMBER: A010777
-- 6 -  UNCLASSIFIED TITLE:         R. F. REMOTE SET
--      INFORMATION LINK STUDY.
--******
-- 1 -  AD NUMBER: 922530L
-- 6 -  UNCLASSIFIED TITLE:         FUZE FUNCTION SELECTOR.
--******
-- 1 -  AD NUMBER: 922527L
-- 6 -  UNCLASSIFIED TITLE:         REPORT OF STUDY FOR FUZE

--      ROCKET: XM433E1 THICK FILM HYBRID ELECTRONIC
--      ASSEMBLY MANUFACTURABILITY.
--******
-- 1 -  AD NUMBER: 921351L
-- 6 -  UNCLASSIFIED TITLE:         COBRA STORES MANAGEMENT
--      AND RC FUZE SETTING SYSTEMS (COBRA STORES TEST).
--******
-- 1 -  AD NUMBER: 906208L
-- 6 -  UNCLASSIFIED TITLE:         FEASIBILITY STUDY FOR A

--      REMOTE SETTABLE FUZE INFORMATION LINK.
--******
-- 1 -  AD NUMBER: 863708L
-- 6 -  UNCLASSIFIED TITLE:         DESIGN AND DEVELOPMENT OF
--      AN ELECTRONIC TIME OPENER AND OPENER SETTER
--      SYSTEM FOR THE TACTICAL FIGHTER DISPENSER.


--******
-- 1 -  AD NUMBER: 766337
-- 6 -  UNCLASSIFIED TITLE:         REMOTE SETTABLE FUZE
--      INFORMATION LINK.
--******
--                                  ******************
--20 - REPORT CLASSIFICATION:        SECRET
--                                  ******************
-- 1 -  AD NUMBER: 527640L
-- 6 -  UNCLASSIFIED TITLE:         RADIO COMMUNICATIONS
--      SYSTEM STUDY.
--******
--                                  ******************
--20 - REPORT CLASSIFICATION:        CONFIDENTIAL
--                                  ******************
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-- 1 - AD NUMBER: 516614L
-- 6 - UNCLASSIFIED TITLE: ANALYSIS OF A BASE-
-- POSITIONED VS. NOSE-POSITIONED FUZE FOR THE 152MM
-- XM617 CARTRIDGE.
--******
-- ******************
--20 - REPORT CLASSIFICATION: CONFIDENTIAL
-- ******************
-- 1 - AD NUMBER: 518396L
-- 6 - UNCLASSIFIED TITLE: DIGITAL TIMER FUZE.
--******
-- 1 - AD NUMBER: 514100
-- 6 - UNCLASSIFIED TITLE: SYSTEM DATA AND BLOCK
-- DIAGRAM FOR PROPOSED 5 IN/54 CALIBER RAPID-FIRE
-- DUAL-PURPOSE LIGHTWEIGHT TWIN GUN MOUNT MARK 66.

--******
-- ******************
--20 - REPORT CLASSIFICATION: SECRET-RD
-- ******************
-- 1 - AD NUMBER: 392709
-- 6 - UNCLASSIFIED TITLE: ENGINEERING REPORT OF
-- REMOTE SETTABLE RADIATION RESISTANT ELECTRONIC
-- TIMER.
--******
-- 1 - AD NUMBER: 915881L
-- 6 - UNCLASSIFIED TITLE: AIRCRAFT AVIONICS
-- TRADEOFF STUDY. VOLUME II. CONCEPT DEVELOPMENT
-- TRADEOFF. PART 1. AVIONICS FUNCTIONS AND
-- REQUIREMENTS.
--******

-- 1 - AD NUMBER: 884176

-- 6 - UNCLASSIFIED TITLE: PYLON STANDARDIZATION AS
-- AN AID TO WEAPON SYSTEM CONFIGURATION CONTROL.
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-- ******************
--20 - REPORT CLASSIFICATION: SECRET
-- ******************
-- 1 - AD NUMBER: 517173
-- 6 - UNCLASSIFIED TITLE: GRC-546-2/JX PROGRAM.
--******
-- 1 - AD NUMBER: 394873
-- 6 - UNCLASSIFIED TITLE: INTEGRATED STORES
-- MANAGEMENT SYSTEMS DESIGN CRITERIA FOR TACTICAL
-- FIGHTER AIRCRAFT.
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DDC DATA BASE: PROGRAMS & PLANS DOCUMENTS

-- 8 - ACCESSION NO (DDC): RA770876
-- 9 - TITLE: (U) STORES MANAGEMENT
--******
-- 8 - ACCESSION NO (DDC): RA770874
-- 9 - TITLE: (U) REMOTE SET FUZING
--******
-- 8 - ACCESSION NO (DDC): RA770215
-- 9 - TITLE: (U) REMOTELY SETTABLE FUZE
--******
-- 8 - ACCESSION NO (DDC): RA760716
-- 9 - TITLE: (U) STORES MANAGEMENT
--******
-- 8 - ACCESSION NO (DDC): RA760714
-- 9 - TITLE: (U) REMOTE SET FUZING
--******
Y

-- 8 - ACCESSION NO (DDC): RA760713
-- 9 - TITLE: (U) AIRCRAFT ROCKET SUBSYSTEMS ASYSTEM
-- (SFAS)
--******
-- 8 - ACCESSION NO (DDC): RA750196
-- 9 - TITLE: (U) REMOTE CONTROLLED FUZE FOR AERIAL
-- ROCKET (2ND GENERATION)
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-- 8 - ACCESSION NO (DDC): RA722895
-- 9 - TITLE: (U)152MM CONVENTIONAL AMMUNITION
--***
-- 8 - ACCESSION NO (DDC): RA720319
-- 9 - TITLE: (U)152 MM CONVENTIONAL AMMUNITION

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--   5 - SUMMARY SECURITY IS:    CONFIDENTIAL
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--   8 - ACCESSION NO (DDC):      RN770061
--   9 - TITLE:       (U)AIR ELECTRONIC WARFARE/CW COUNTER
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--******
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--   9 - TITLE:       (U)ADVANCED SUSPENSION AND RELEASE
--     EQUIPMENT
--****
--
--   5 - SUMMARY SECURITY IS:    CONFIDENTIAL
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--   8 - ACCESSION NO (DDC):      RN750929
--   9 - TITLE:       (U)AIR WEAPONS LAUNCHING/HANDLING/
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--   8 - ACCESSION NO (DDC):      RN750895
--   9 - TITLE:       (U)ADVANCED WEAPONS CONTROL TECHNOLOGY
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--******
--   8 - ACCESSION NO (DDC):      RN740303
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--******
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--   8 - ACCESSION NO (DDC):      RN740300
--   9 - TITLE:       (U)AIR WEAPONS LAUNCHING/HANDLING/
--     SERVICING TECHNOLOGY
--******
--   8 - ACCESSION NO (DDC):      RF771045
--   9 - TITLE:       (U)STORES MANAGEMENT TECHNOLOGY
Y

--******
--   8 - ACCESSION NO (DDC):      RF771043
--   9 - TITLE:       (U)FUZING TECHNOLOGY
--******
--   8 - ACCESSION NO (DDC):      RF771027
--   9 - TITLE:       (U)CONVENTIONAL WEAPONS
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--   8 - ACCESSION NO (DDC):      RF770998

--   9 - TITLE:       (U)(U) CONVENTIONAL WEAPONS TECHNOLOGY
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--   8 - ACCESSION NO (DDC):      RF770986
--   9 - TITLE:       (U)(U) FUZING TECHNOLOGY
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--   8 - ACCESSION NO (DDC):      RF770952
--   9 - TITLE:       (U)FUZING TECHNOLOGY
Y

--******
--   8 - ACCESSION NO (DDC):      RF770947
--   9 - TITLE:       (U)STORES MANAGEMENT TECHNOLOGY
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--   8 - ACCESSION NO (DDC):      RF770933
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--   8 - ACCESSION NO (DDC):      RF770229
--   9 - TITLE:       (U)DAIS/STORES MANGEMENT INTERFACE
--******
--   8 - ACCESSION NO (DDC):      RF770222
--   9 - TITLE:       (U)VISUALLY COUPLED SYSTEMS APPLICATIONS
--     TO DAIS
--******
Y
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THIS PAGE IS BEST QUALITY PRACTICABLE FROM COPY FURNISHED TO DDC

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--   8 - ACCESSION NO (DDC):    RF760315
--   9 - TITLE:      (U)(U) CONVENTIONAL WEAPONS TECHNOLOGY
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--   8 - ACCESSION NO (DDC):    RF760309
--   9 - TITLE:      (U)(U) FUZING TECHNOLOGY
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--   8 - ACCESSION NO (DDC):    RF760287
--   9 - TITLE:      (U)(U) MUNITION/AIRCRAFT INTERFACE
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--******
--   8 - ACCESSION NO (DDC):    RF760081
--   9 - TITLE:      (U)CONTROL-DISPLAY FOR AIR FORCE AIRCRAFT
--     AND AEROSPACE VEHIC
--******
--   8 - ACCESSION NO (DDC):    RF760041
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--   9 - TITLE:      (U)DIGITAL AVIONICS INFORMATION SYSTEM
--     (DAIS) SYSTEM INTEGRAT
--******
--   8 - ACCESSION NO (DDC):    RF750330
--   9 - TITLE:      (U)(U) MUNITION/AIRCRAFT INTERFACE
--     TECHNOLOGY
--******
--                              ******************
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--   8 - ACCESSION NO (DDC):    RF740998
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--   9 - TITLE:      (U)MWS WEAPON MANAGEMENT SYSTEM
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--   8 - ACCESSION NO (DDC):    RF740946
--   9 - TITLE:      (U)MWS WEAPON MANAGEMENT SYSTEM
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--   9 - TITLE:      (U)BOMB AND FUZES
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--   8 - ACCESSION NO (DDC):    RF740912
--   9 - TITLE:      (U)ADVANCED CONCEPTS IN RACK DESIGN
--******
Y

--   8 - ACCESSION NO (DDC):    RF740190
--   9 - TITLE:      (U)ADVANCED CONCEPTS IN RACK DESIGN
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--   8 - ACCESSION NO (DDC):    RA770876
--   9 - TITLE:      (U) STORES MANAGEMENT
--******
--   8 - ACCESSION NO (DDC):    RA770874
--   9 - TITLE:      (U) REMOTE SET FUZING
--******
--   8 - ACCESSION NO (DDC):    RA760716
--   9 - TITLE:      (U) STORES MANAGEMENT
--******
--   8 - ACCESSION NO (DDC):    RA760714
--   9 - TITLE:      (U) REMOTE SET FUZING
--******
Y

--   8 - ACCESSION NO (DDC):    RA760713
--   9 - TITLE:      (U) AIRCRAFT ROCKET SUBSYSTEMS HSYSTEM
--     (SEAS)
--******
--   8 - ACCESSION NO (DDC):    RA750209
--   9 - TITLE:      (U) EXTERNAL STORES MANAGEMENT SUBSYSTEM
--     FOR ATTACK HELICOPTER
--******
--   8 - ACCESSION NO (DDC):    RA750195
--   9 - TITLE:      (U) 2.75 INCH ROCKET PRODUCT IMPROVEMENT
--     PROGRAM
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DDC DATA BASE: IR&D DATA

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--IR&D DATA ARE PROPRIETARY - FURTHER RELEASE IS PROHIBITED.
--     *          *          *          *          *
--   A - ACCESSION NUMBER:     76035040
--   5 - PROJECT TITLE:   ADVANCED AIRCRAFT ELECTRICAL
--       SYSTEM (AAES) SIGNAL POWER MULTIPLEXING
--******
--IR&D DATA ARE PROPRIETARY - FURTHER RELEASE IS PROHIBITED.
--     *          *          *          *          *
--   A - ACCESSION NUMBER:     76028602
--   5 - PROJECT TITLE:   SIGNAL CONVERSION AND MUX
--******
--IR&D DATA ARE PROPRIETARY - FURTHER RELEASE IS PROHIBITED.
--     *          *          *          *          *
--   A - ACCESSION NUMBER:     76004482
--   5 - PROJECT TITLE:   ANTISUBMARINE WARFARE (ASW)
Y

--       NONACOUSTIC SYSTEMS TECHNOLOGY
--******
--IR&D DATA ARE PROPRIETARY - FURTHER RELEASE IS PROHIBITED.
--     *          *          *          *          *
--   A - ACCESSION NUMBER:     76002849
--   5 - PROJECT TITLE:   STORES MANAGEMENT
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--IR&D DATA ARE PROPRIETARY - FURTHER RELEASE IS PROHIBITED.
--     *          *          *          *          *
--   A - ACCESSION NUMBER:     75007903
--   5 - PROJECT TITLE:   DIGITAL INTEGRATED AVIONICS
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--IR&D DATA ARE PROPRIETARY - FURTHER RELEASE IS PROHIBITED.
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--   A - ACCESSION NUMBER:     75004557
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--   5 - PROJECT TITLE:   ANTISUBMARINE WARFARE (ASW)
--       NONACOUSTIC SYSTEMS TECHNOLOGY
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--IR&D DATA ARE PROPRIETARY - FURTHER RELEASE IS PROHIBITED.
--     *          *          *          *          *
--   A - ACCESSION NUMBER:     75002831
--   5 - PROJECT TITLE:   STORES MANAGEMENT SYSTEM
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--IR&D DATA ARE PROPRIETARY - FURTHER RELEASE IS PROHIBITED.
--     *          *          *          *          *
--   A - ACCESSION NUMBER:     75002035
--   5 - PROJECT TITLE:   RADAR DEVELOPMENT AND
--       ENHANCEMENT
--******

--IR&D DATA ARE PROPRIETARY - FURTHER RELEASE IS PROHIBITED.
--     *          *          *          *          *
--   A - ACCESSION NUMBER:     76030834
--   5 - PROJECT TITLE:   ROCKET FIRE CONTROL
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--IR&D DATA ARE PROPRIETARY - FURTHER RELEASE IS PROHIBITED.
--     *          *          *          *          *
--   A - ACCESSION NUMBER:     76012045
--   5 - PROJECT TITLE:   FUZE SETTING COMMUNICATIONS
--       LINK (PHASE II) (FUZING)
--******
```

DDC DATA BASE: WORK UNIT SUMMARIES (1498)
-- WUIS STATISTICS PAGE 1 OF 2 FEB 01, 1977

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--TOTAL-SEARCH FINDS**----------------     5     ARMY--     4
-- FIRST LEVEL FINDS**----------------    45     NAVY--     1
-- FIRST AND SECOND LEVEL FINDS**----      5     AF----     0
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--   1 - AGENCY ACCESSION NO:    DN234554
--  11 - TITLE:      (U)  SMALL CALIBER PROJECTILE FUZING
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--   1 - AGENCY ACCESSION NO:    DA0F5657
--  11 - TITLE:      (U)  REMOTE SET FUZING FOR 2.75 IN ROCKET
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--   1 - AGENCY ACCESSION NO:    DA0F5642
--  11 - TITLE:      (U)  REMOTE SET ELECTRONIC TIMER
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--   1 - AGENCY ACCESSION NO:    DA0F5636
--  11 - TITLE:      (U)  ANALYTICAL INVESTIGATION OF

--      INDUCTIVE LOOP COUPLING FOR REMOTE SET FUZING
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--   1 - AGENCY ACCESSION NO:    DA0A5815
--  11 - TITLE:      (U)  ADVANCED ARTILLERY ELECTRONIC TIMER
--      INVESTIGATION AND ANALYSES

--   1 - AGENCY ACCESSION NO:    DN682218
--  11 - TITLE:      (U)  F-18 STORES MANAGEMENT SYSTEM
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--   1 - AGENCY ACCESSION NO:    DN682195
--  11 - TITLE:      (U)  BASELINE REQUIREMENTS, NAVY AIRCRAFT
--      STORES MANAGEMENT USYSTEMS
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--   1 - AGENCY ACCESSION NO:    DN682030
--  11 - TITLE:      (U)  F-18 TECHNICAL SUPPORT
--******
--   1 - AGENCY ACCESSION NO:    DN682019
--  11 - TITLE:      (U)  AIR STRIKE WARFARE WEAPONRY
--      TECHNOLOGY BLOCK PROGRAM WF32- U300 B01 (NWC).
--******

--   1 - AGENCY ACCESSION NO:    DN681001
--  11 - TITLE:      (U)  A-4KU/TA-4KU RECONNAISANCE POD
--      SYSTEM DEVELOPMENT
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--   1 - AGENCY ACCESSION NO:    DF639830
--  11 - TITLE:      (U)  STORES MANAGEMENT FLIGHT TEST
--      SOFTWARE DEVELOPMENT
--******
--   1 - AGENCY ACCESSION NO:    DF638530
--  11 - TITLE:      (U)  FUZE FUNCTION SELECTOR FOR DISPENSER
--******
--   1 - AGENCY ACCESSION NO:    DF637800
--  11 - TITLE:      (U)  ANALYSIS OF HARDWIRED VS MULTIPLEXED
--      STORES MANAGEMENT SYSTEMS
--******

--   1 - AGENCY ACCESSION NO:    DF637610
--  11 - TITLE:      (U)  PILOTS CONTROL PANEL
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--   1 - AGENCY ACCESSION NO:    DF636310
--  11 - TITLE:      (U)  STORES MANAGEMENT SYSTEM INTEGRATION
--      AND TEST
--******
--   1 - AGENCY ACCESSION NO:    DF636300
--  11 - TITLE:      (U)  STORES MANAGEMENT HARDWARE
--      SIMULATORS
--******
--   1 - AGENCY ACCESSION NO:    DF636290
--  11 - TITLE:      (U)  STORES MANAGEMENT HOT BENCH
--******
--                                  ******************

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--                                  GDS(81)
--                                  ******************
--   1 - AGENCY ACCESSION NO:    DF105150
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--   1 - AGENCY ACCESSION NO:    DF100420

--  11 - TITLE:      (U)  DAIS MISSION SOFTWARE SPECIFICATION
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APPENDIX C

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

REFERENCE OR OFFICE SYMBOL	SUBJECT
DRXDO-DAD	Minutes of Meeting, Ad Hoc Committee for Remote Set

TO Attendees FROM R. Goodman, HDL DATE 16 May 1977 CMT 1
Mr. Goodman/dw/42440

1. The subject meeting was held on 3 and 4 May 1977 at HDL. An attendance list is attached.

2. Bob Goodman reviewed the status of the study requested of the WPFF by the JFTG. The objectives of the study, as outlined in the task objectives issued previously, were reviewed along with the schedule.

3. The principal milestones are a formal presentation to the JFTG on 17 June 1977 and a final report on 30 June 1977. Sometime after 17 June the committee will also report to the Fuze Management Board.

4. The members of the committee then reviewed the principal remote set programs. A list of programs and technologies was made, then organized into a chart (Attachment 2). These were discussed by the cognizant developers: Bob Goodman, Pete Weldon, Pat Ward, Dick Swenson, and Roger Sitaramiah.

Projectiles and Rockets

GSRS (HDL)
RBOC/ROC (HDL)
5, 8 inch GP data links (HDL)
5, 8 inch Fuze/Function Setter (NSWC/WOL)
RF RS Fuze for Artillery and Tanks (ARRADCOM)
First Generation 2.75 inch Rocket (ARRADCOM)
Second Generation 2.75 inch Rocket (HDL)

Bombs, Stores Management, Aircraft Stores, etc.

SLU-FAE (WOL)
SLU-MINE (WOL)
Digital Bomb Fuze (WOL)
RASS (NWC/CL)
Bulldog (NWC/CL)
Harpoon (NWC/CL)
Opal (NWC/CL)
DIMAS (NWC/CL)
WALLEYE I (NWC/CL)
WALLEYE II (NWC/CL)
CONDOR (NWC/CL)
BULLPUP (NWC/CL)
Digital Bomb Fuze (NWC/CL)
Tomahawk (NWC/CL)
Maverick (NWC/CL)

4. A letter was also read from Bob Ehrhart of the Air Force. He noted that the Air Force does not now or in the foreseeable future have plans for cockpit selectable options or remote set. However, Dick Swenson did point out that the long term development of a universal microcomputer controlled Stores Management and Setting System would have application to Air Force systems if the AF had a change of heart.

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DA FORM 1 FEB 62 2496 REPLACES DD FORM 96, WHICH IS OBSOLETE. ☆GPO-1975-665-422/1063

DRXDO-DAD
SUBJECT: Minutes of Meeting, Ad Hoc Committee for Remote Set

5. There were other areas in the tech base that were discussed other than those technologies with direct application to systems. These were a low frequency (10 MHz) RF data link with FSK modulation, an acoustic vibration link which both HDL and Picatinny Arsenal had considered earlier, and an optical data link in which both power and data were transferred optically.

6. Some newer applications were also reviewed. Pete Weldon discussed rf setting after launch for new anti-tank/anti-aircraft munitions and pointed out that the rf system could also measure muzzle velocity and make last second corrections.

7. Attachment 2 was then developed. Each column was assigned to a principal developer of an applicable system. He was to summarize each technology (left hand column) for the application, including its advantages and disadvantages and why this development was not contributing to proliferation. This data was to be mailed by 16 May to each attendee to be available prior to the next meeting.

8. Finally, it was decided that another meeting be held on 24 May. At this meeting the final report would be drafted, important issues identified and consensus reached on positions to be taken by the committee.

Some of the considerations for the study were: (1) Multiple approaches should be considered through 6.3A since no data link was obviously good for all applications; (2) Universal coding formats should be considered, (3) The committee should make some hard recommendations if it is to be responsive to the goals of the JFTG.

9. An outline for the study was proposed.

1. Purpose of Study

2. Scope
   (Define Remote Set)

3. Approach
   Division of Work
   Literature Search
   Membership

4. Description of Systems

5. Harmonization Considerations
   (How to achieve, degree of proliferation, outlook for new weapons systems, effect of competition)

DRXDO-DAD
SUBJECT: Minutes of Meeting, Ad Hoc Committee for Remote Set

6. Recommendations
(Conclusions, MIL-STD's, JSOR's, etc.)

7. Appendices
(Literature search, bibliography)

10. Action Items:

a. Mail out discussions of Attachment 2 by 16 May

b. Next meeting 24 May at 0830 Hours at HDL.

c. Start final report.

ROBERT S. GOODMAN
Chairman

Incl as

JFTG REMOTE SET FUZE MEETING

3 May 1977

ATTENDEES

NAME	ORGANIZATION	OFFICE SYMBOL	PHONE
R. S. Goodman	HDL	DRXDO-DAD	(202) 394-2440 (AV) 290-2440
B. Scheiner	HDL	DRXDO-DAD	(202) 394-2440 (AV) 290-2440
Roger Sitaramiah	ARRADCOM	DRDAR-LCF-S	(201) 328-4909
Sid Englander	NAVAIR	AIR 5324	(AV) 222-3848
William J. Ryan	JFTG	DRCDE-JFTG	(202) 394-2812 (AV) 290-2812
Frank Vrataric	JFTG	DRCDE-JFTG	(202) 394-2812 (AV) 290-2812
Pete Ward	NSWC	WA-33	(202) 392-2580
Pete Weldon	ARRADCOM	DRDAR-LCF	(AV) 880-6476
Dick Kaiser	MIRADCOM	DRCPM-RK	(AV) 746-3201
Dick Swenson	NWC	Code 3353	(714) 939-7323 (AV) 245-7323

ATTACHMENT 1

Communication Link	Weldon	Weldon	Sitaramiah Scheiner	Weldon	Ward	Swenson	Swenson	Ward	Goodman	Kaiser	Goodman	Weldon	Swenson
	Tank Proj	Gun Proj	Heli-copter Rocket	Fixed Wing Rockets	Fixed Wing Bombs	Missiles	Smart Bombs	Ship Proj	GSRS	Slammer	Decoys	Mines	Stores Mgmt.
Radio Frequency	F3[m]	P[m]	P[m]	P[m]	A[m]			A[m]	A[m]	A[m]	A[m]		
Inductive	A[a(b)]		F3[b]	A[b]				F3[c]	A[b]	A[b]	F3[d]	F4[e]	
Hardwire			TCLP[f]	A[f]	TC[g]	TC	TC	A[o]	F3[h]A[p]	A[f]			
Mechanical								TC[i]					
Optical			A[j]		A[j]	A[j]	A[j]	A[k]					A[q]
X-Ray					A[n]								
Acoustic	A[l]	A[l]	P[l]		A[l]			A[l]					

F - Funded
P - Proposed
A - Applicable
TC - Type Classified

a - HIMAG proposal
b - 2.75" rocket system, 2nd generation
c - 5" data link
d - RBOC-ROC-Special Time system
e - GEMSS
f - 2.75" rocket (M433/439 Analog Digital)
g - AWW/4
h - XM587 system
i - M732/M728/Mech Time
j - OPAL
k - Communication link - other than OPAL
l - Acoustic vibration
m - HEMP
n - RASS
o - XM587/XM36E1
p - ARRADCOM GSRS
q - DIMAMS

ATTACHMENT 2

APPENDIX D

D1. REMOTE SETTING OF TANK PROJECTILES

Setting fuzes on tank rounds is becoming an increasing concern of the Armor community. This is due in large part to the increased threat of anti-tank weapons launched by troops and helicopters.

Presently, the M571 mechanical time fuze is used to airburst the M494 projectile. Since the Armor community is highly desirous of replacing this fuze due to its poor reliability and inaccuracy, the XM742 hand-settable electronic time fuze is presently in Engineering Development as a replacement for the M571. This new fuze will provide the tank with increased effectiveness through better utilization of the M494 round.

Optimum effectiveness can be achieved by incorporating remote setting. This will provide a tank with increased firing rate and faster response time by eliminating hand setting and directly interfacing the fire control system with the accurate electronic fuze.

Several communication link technologies can be considered for remote setting tank fired projectiles. Among these are the radio frequency (RF), inductive and acoustic systems.

D1-1 Radio Frequency Remote-Set System for Tank Cannon Projectiles

The RF remote-set system described in Appendix D3 is currently in advanced development (6.3) for tank ammunition. The objective of radio frequency remote-set fuzing program is to design, develop and test a remotely settable fuze and its information link for large caliber tank gun ammunition systems.

During a Qualitative Requirements Information Program, Problems 15-87, 15 April 1970, several types of remote-set fuzing systems were investigated. A radio frequency link was chosen because it minimizes the mechanical and electrical interfaces between an existing weapon and its ammunition. No modification to the gun is required for RF remote-set fuzing. After the round is fired, a microwave transmitter mounted on the vehicle and operating from vehicle power automatically sends range information as a burst of pulses to a

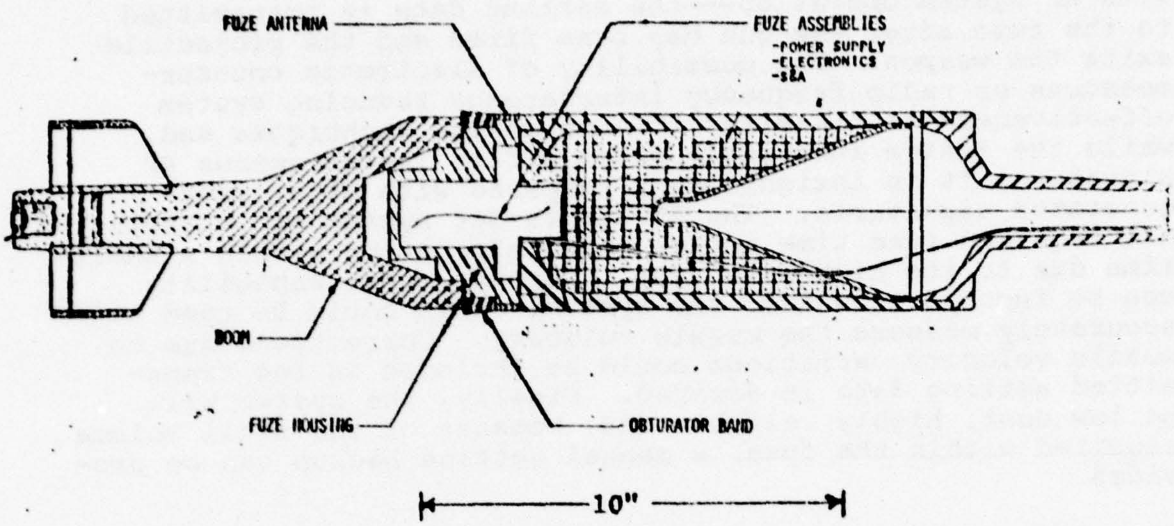
receiver located in the fuze. This occurs when the round is less than twelve (12) feet from the muzzle.

RF technology can be utilized in several tank applications:

a. The RF remote-set fuzing system, when integrated with automatic fire control systems found in M60A3 and XM-1 tanks, will provide faster and more effective fire power against helicopters and troops equipped with anti-tank weapons by eliminating hand setting and reducing human error. In combat, M494 Beehive Flechette rounds could either be chambered or loaded instantly for faster response against a threat such as troops or a helicopter attacking with anti-tank guided missiles. No modification to the existing M494 round is required to equip it with the RF remote-set fuzing system and the stockpile may be retrofitted by simply changing the fuze.

b. The RF remote-set fuzing system is applicable to a round being considered for the XM-1, if 120 mm is chosen as the main gun caliber. This round would be multi-purpose with high explosive anti-tank (HEAT) and airburst fragmentation functions and would replace the HEAT, high explosive plastic (HEP) and Beehive rounds currently carried on-board tanks. Potential targets are armored vehicles (in the HEAT mode) and buildings, bunkers, unarmored vehicles, helicopters, and personnel (such as Saggar ATGM squads). RF remote-set fuzing would be an integral part of this round. Setting information will be transmitted to the fuze after firing from a tank-mounted transmitter interfaced with the ballistic computer/fire control system of the tank. This information would include selection from anti-tank (HEAT), impact, delay-after-impact or time-to-airburst function.

A concept investigation was performed using the 120 mm, M469 fin stabilized HEAT round as a reference projectile. In the sketch of this proposed high explosive multi-purpose (HEMP) round shown below, the spike and the shaped charge of the M469 remain unchanged. The addition of a mid-mount fuze housing requires a minor change in the method of connection to the warhead body. The boom, which requires redesign to provide a large fuze cavity, will be tailored after the 105mm M456 boom.



120mm HEMP (HIGH EXPLOSIVE MULTIPURPOSE) PROJECTILE WITH MID-MOUNT RF REMOTE-SETTABLE FUZE

c. Current developments have made feasible a medium or light weight armored vehicle with a stabilized medium caliber weapon (60-90 mm) capable of a high rate of fire. A kinetic energy round with subcaliber penetrator would be employed offensively against armored targets. To provide defense against ground or airborne attacks either a multiple flechette (Beehive type) or high explosive proximity round will be carried. Setting data from the vehicles' fire control system could be communicated to these latter two rounds via a radio frequency link. This could serve to turn-on a proximity fuze, airburst the round or select another mode of operation.

The RF remote-set system for tank projectiles has several features. No modifications are required to the weapon as only a small, rugged antenna must be mounted on the vehicle exterior. The system requires no special action by the loader such as hand-setting or holding a round in a fuze setter to operate. Firing of the weapon is integral

with RF system operation---the setting data is transmitted to the fuze after the gun has been fired and the projectile exits the weapon. The possibility of electronic countermeasures or radio frequency interference reducing system effectiveness is minimized through design techniques and, while the system inherently gives off an instantaneous RF signature, it is insignificant compared with other tank-generated signatures. The RF remote-set system can transmit all required fuze time and/or mode information within a short time due to its high data rate. Doppler radar capability can be incorporated into the system. This could be used to accurately measure the muzzle velocity. Corrections due to muzzle velocity variations could be included in the transmitted setting data is desired. Finally, the system will be low cost, highly reliable and, because of the small volume required within the fuze, a manual setting backup can be provided.

D1-2 Inductive Link Remote-Set for Tank Projectiles

The inductive link remote-set system may be considered for use in tank applications requiring remote setting. This link has not been proposed for use in the M-60 or XM-1 series tanks but is being used in other systems. For the Navy the inductive link is being developed for ship projectiles and decoys and for MIRADCOM, it is being considered for the second generation of the 2.75" helicopter launched rocket system. Specifics of these applications are discussed in other portions of this report.

From a tank projectile view point the inductive link has the following characteristics:

a. With its localized radiation it does not generate a detectable signature and has low susceptability to EMI.

b. If the transmitting coil was located on the muzzle, difficulty would be encountered in repeatedly surviving the muzzle blast. Also, problems would arise in maintaining reliable wire routing down the gun tube and across the recoil mechanism.

c. For a breech-mounted transmitting coil, considerable modification would be required of the breech mechanism. Also, the round could not be loaded before setting--thus a

tank could not chamber a round for fastest response against an anticipated threat.

d. The inductive link has not demonstrated a muzzle velocity measurement capability.

e. The data rate is low in comparison with other communication link technologies.

While the inductive link has not been proposed for M-60 and XM-1 series tanks, it should be considered for new developments of tank-type weapons such as HIMAG. Depending on specific system requirements and flexibility in modifying the gun mechanism, not only the inductive link but also a hardwire system should be investigated.

D1-3 Acoustic Remote-Set System for Tank Projectiles

The acoustic link remote-set system might be applicable for use in tank projectiles requiring remote setting. One system investigated by ARRADCOM established a remote-set fuze communication link through the application of ultrasonic principles. These principles utilize the resonant mode transfer function characteristics of the gun-projectile system. This linkage system allows for the transmission of range time information, via vibration signals and mechanical coupling paths, to an electronic fuze of a chambered projectile from a fire control system. A vibration controlled remote-set fuze was designed and techniques for generating on-board operating power through piezoelectric action were developed.

The acoustic link has the following characteristics pertinent to a tank system:

a. The system is not vulnerable to ECM or EMI.

b. Uncertainty exists in the coupling between the gun and the projectile.

c. A transmitting transducer must mechanically interface with the gun tube.

d. The link has an inherently slow data rate.

e. Projectile velocity measurement cannot be realized.

f. A backup manual setting mode is not provided.

CONCLUSION

Of all the communication link technologies, radio frequency remote-set fuzing is presently an appropriate choice for tank fired projectiles. Reasons for this include: The tank is a well-established weapon system with particular requirements and constraints; addition of the RF link requires the least modification of the tank system; disadvantages of the RF link for a tank application are minor; advantages of the RF link surpass those of other technologies.

D2. REMOTE SETTING OF ARTILLERY PROJECTILES

Many artillery projectiles require fuze setting before they are fired. This operation can include a simple choice of option or something more involved such as selecting time-to-function. In either case, the manual operation takes time and is a source of potential human error.

Remote setting of these projectiles can reduce this time and error--thus making artillery fire more responsive and effective. Especially in conjunction with the TACFIRE/BCS system, remote setting could best provide the most up-to-date fuze setting based on the latest target information.

Two communication link technologies can be considered for remote setting artillery projectiles. These are the radio frequency (RF) and the acoustic systems.

D2-1 Radio Frequency Remote-Set System for Artillery Projectiles

The RF remote-set system, described in Appendix D3, is currently in advanced development for tank ammunition and has been proposed for artillery applications. During exploratory development, a feasibility study for a radio frequency remote-set information link for use with artillery ammunition was performed. This effort included the design, development and testing of such a system. A prototype transmitter was developed with Doppler radar capability to determine instant of muzzle exit and then transmit fuze setting signal. A receiver, compatible with XM742 Fuze CMOS circuitry was developed. Laboratory tests confirmed RF performance while air gun testing by ARRADCOM showed survivability under condition of gun launch. Successful demonstrations of the RF remote system during live firings of the prototype fuzes from a 105mm Howitzer proved the feasibility of sending a setting signal via RF after firing and thus, the feasibility of this system.

When applied to artillery, the RF system has several features. No modifications are required to the artillery piece as only a small, rugged transmitter/antenna must be located to illuminate the muzzle region. To operate the system requires no special action by the crew such as hand

setting or mating the fuze with a setter. Firing of the weapon in conjunction with the TACFIRE/BCS system is integral with the RF fuze setting operation--the data is transmitted to the fuze after the gun has been fired and the projectile exits the weapon. The possibility of electronic countermeasures or radio frequency interference reducing system effectiveness is minimized through design techniques and, while the system inherently gives off an instantaneous RF signature, it is insignificant compared with other artillery generated signatures. The RF remote-set system can transmit all required fuze time and/or mode information within a short time due to its high data rate,doppler radar capability can be incorporated into the system. This could be used to accurately measure the muzzle velocity. Corrections due to muzzle velocity variations could be included in the transmitted setting data if desired. Finally, the system will be low cost, highly reliable and, because of the small volume required within the fuze, a manual setting backup can be provided.

D2-2 Acoustic Remote-Set System for Artillery Projectiles

The acoustic link remote-set system might be applicable for use in artillery projectiles requiring remote setting. One system investigated by ARRADCOM established a remote-set fuze communication link through the application of ultrasonic principles. These principles utilize the resonant mode transfer function characteristics of the gun projectile system. This linkage system allows for the transmission of range time information, via vibration signals and mechanical coupling paths, to an electronic fuze of a chambered projectile from a fire control system. A vibration controlled remote-set fuze was designed and techniques for generating on-board operating power through piezoelectric action were developed.

From the artillery viewpoint, the acoustic link has the following characteristics:

a. The system is not vulnerable to ECM or EMI.

b. Uncertainty exists in the coupling between the gun and the projectiles.

c. A transmitting transducer must mechanically interface with the gun tube.

d. The link has an inherently slow data rate.

e. Projectile velocity measurement cannot be realized.

f. A back-up manual setting mode is not provided.

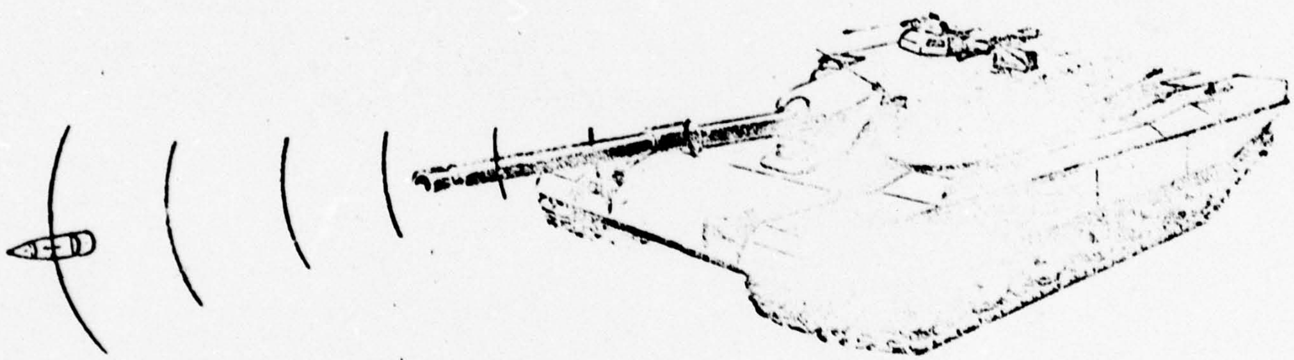
CONCLUSION

Of the two applicable communication link technologies, RF remote-set fuzing is the most appropriate choice for artillery projectiles. This is due to the fact that the artillery piece is a well established weapon system with particular requirements and constraints. To add the RF setting link requires the least modification of the weapon system while providing more advantages than other communication link technologies.

D3. RADIO FREQUENCY (RF) REMOTE-SET COMMUNICATION LINK

D3-1 Description of the System

The ARRADCOM RF remote-set fuzing system utilizes a radio frequency link to communicate with munitions after launch. The weapon fire control system supplies fuze setting information to a microwave transmitter, mounted on the vehicle and operating from vehicle power, which sends a burst of setting pulses to a receiver located in the fuze. The receiver, which is an integral part of the fuze, accepts these radio frequency pulses and, after processing, provides the fuze circuitry with the proper setting. Shortly after being set, the fuze electronics turn the receiver off to conserve power and prevent countermeasures. The entire setting process occurs within five (5) meters of the weapon. This concept for a tank application is illustrated below.



REMOTE-SET FUZING CONCEPT (TANK CONFIGURATION)

D3-2 Discussion of Work-to-Date

Exploratory development, to prove the feasibility of the remote-set system concept, has been completed. This work proceeded in phases, which are briefly described below.

1. Controlled Range Airburst (CRAB) Fuze demonstrated feasibility of transmitting RF pulses to a fuze in flight. An off-the-shelf radar set sent continuous pulses which were received and filled a counter in the fuze. Function time varied with rate of pulse transmission. Ballistic tests from a 105mm, M2A2 Howitzer resulted in six (6) of nine (9) fuzes functioning as expected.

2. Artillery Remote-Set Fuze established the ability to set a fuze by one burst of pulses immediately outside the gun tube. Prototype transmitter was developed with Doppler radar to determine instant of muzzle exit and with future capability of supplying muzzle velocity data. Beehive electronic fuze components were successfully used in a remote-set system. RF attenuation tests verified the signal could be transmitted before interference from howitzer produced gun gas cloud inhibited the signal. Ballistic tests conducted with a 105mm Howitzer showed the remote-set system information link operated as expected.

3. 2.75" Rocket Remote-Set Fuze utilized artillery remote-set technology for rocket ordnance. Modifications were made to adapt the fuze for operation in a low-g environment. Four (4) of five (5) test shots were effective and demonstrated the feasibility of the remote-set system in rocket fuzes. Hardware to implement a multi-option remote-set fuze was developed and successfully tested in the laboratory.

Additional areas have been investigated during Advanced Development. These were directly applicable to a tank environment but also supplied information for other applications.

The first area dealt with the fireball which forms when the gun is fired. To determine how this might effect the RF remote setting, an extensive test program was conducted to measure the level and timing of the RF attenuation resulting from the fireball. This effort is documented in the report "R.F. Remote Set Fuzing Test and Analysis" by M.D. Egtvedt et.al., December 1976 under contract DAAA-21-76-C-0241. Briefly, the primary conclusion is "close-in communication to Remote Set fuzes fired from an M68 tank cannon can be realized."

A second investigation was performed to assess the vulnerability of the RFRS system to radio frequency interference (RFI)——both intentional (jamming) and unintentional.

A study was performed by Quest Research Corporation under contract DAAA-21-76-C-0145. The final report (S) "Vulnerability of the RF Remote Set Fuze System to RFI and ECM(U)," October 1976 basically states that jamming of the RFRS system is very impractical and unintentional interference is extremely unlikely.

An effectiveness study is presently underway to evaluate the RF remote-set fuzing system when utilized by a tank engaging an attacking helicopter. This study will be attached as an appendix to the draft LOA which is presently being staffed.

D3-3 Anticipated Design

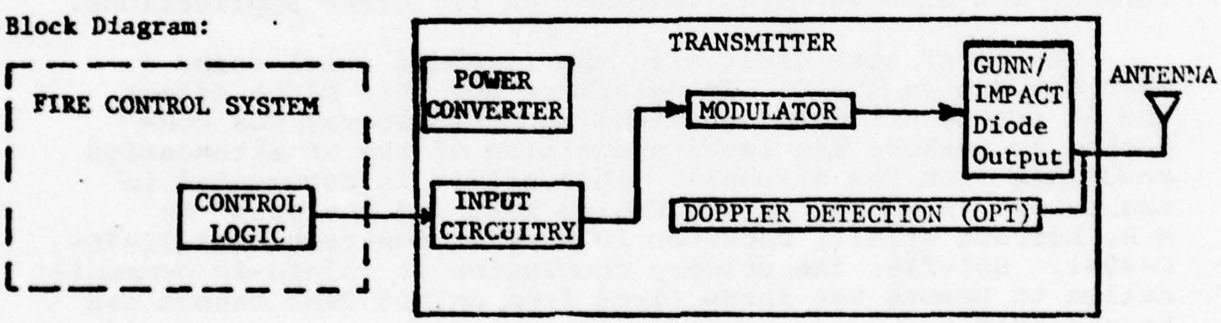
Since the RF information link is the heart of the RF remote-set Fuzing system, the main components of this link, (the transmitter and receiver) can be virtually identical for all system applications.

Transmitter

Characteristics:

Frequency: X band or Ku band
Power: 1 - 10 watts
Antenna type: Stripline, externally mounted, 4"x4"x0.5"
Transmitter type: IMPATT or Gunn Diode
Connection to control: 3 conductor cable

Block Diagram:



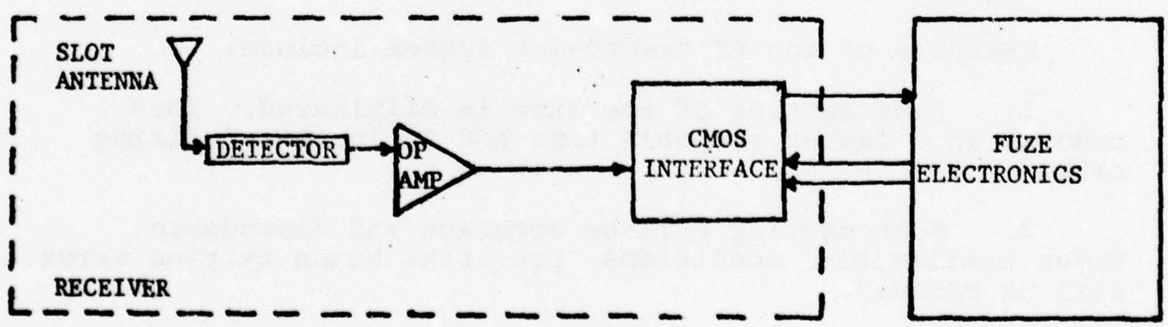
This transmitter would be rugged, small, solid state and easily installed in either a new weapon system or retro-fitted into an existing weapon system. Full utilization would be made of the circuitry already available in the fire control system to provide the transmitter with an appropriate signal for transmission. System capabilities could include Doppler radar for detection of projectile muzzle exit and for determination of projectile muzzle velocity for use as a factor in determination of fuze function time if desired. A small, flat, simple and extremely rugged stripline antenna would be mounted on the weapon platform with connection to the transmitter via coaxial cable. It is estimated that a transmitter can be packaged in a 7" x 7" x 3.5" container at a cost of $1,000 - $1500, (excluding installation). Costs would be comparable for installation in other weapon systems which include a ballistic computer as part of the fire control system.

Receiver

Characteristics:

Frequency: X band or Ku band
Antenna: located within fuze dimensions
Detector type: RF diode
Signal amplification: Operational amplifier
Gating and output circuitry: CMOS
Power required: 20,000 ergs from fuze power supply

Block Diagram:



Components and techniques already proven in the XM742 Beehive Electronic Fuze will be utilized for receiver electronics. A custom integrated circuit will be developed to perform necessary receiver functions including low level signal amplification, signal processing and interface with fuze electronics.

Fuze

The fuze electronics will be similar to those in the XM742 and will consist of the following:

1. Power Supply--It will be a setback generator. Electrical energy will be generated when the round is fired and stored in a capacitor. It has a very fast rise time, and is extremely rugged. Setback generators have been fired successfully in 105mm guns, 152mm guns and in 2.75" rockets and provide sufficient energy.

2. Oscillator--A crystal oscillator or LC oscillator will be used. Either will be low cost, consume very little electrical energy, be very accurate and occupy a small volume. The LC oscillator has been proven in the XM742 while the crystal oscillator is being mass produced for digital watches.

3. Logic and timing circuits--These will be on one CMOS (complementary metal oxide semiconductor) integrated circuit. This type of IC has been used usccessfully in many fuze programs and is compatible with both oscillators.

D3-4 Features

Features of the RF Remote-Set system include:

1. Hand setting of the fuze is eliminated. This results in a faster response time and an increased firing rate.

2. Fuze setting will be accurate and dependable. Under battlefield conditions, potential human setting error will be reduced.

3. RF remote-set fuzing will be reliable. This is due to the use of the extremely short distance over which

the signal must be transmitted, and careful choice of circuitry and operating frequency. A monitor circuit in the transmitter will verify that a setting signal has actually been sent.

4. Fuze will be set with the most up-to-date information. The laser range-finder which accurately locates the target distance will provide an input to the ballistic computer. This, in addition to other system variables, will be utilized by the computer to determine the proper fuze setting. Setting actually occurs after the weapon is fired.

5. Doppler radar capability could be incorporated into the RF remote-set fuzing system. This could be used to accurately determine the muzzle velocity. Corrections due to muzzle velocity variations could be included in the transmitted setting data if desired.

6. RF remote-set system could be used with a multi-purpose round. Coded data can be transmitted to determine type of fuze functioning (superquick, delay after impact, airburst, etc.) as well as the time of fuze functioning.

7. Fuze contains a back-up setting device. This will provide a means to manually set the fuze if desired.

8. Remote-set fuze is obtained by adding a receiver to the Beehive Electronic Fuze being developed by ARRADCOM. This digital fuze is designed for high reliability and accuracy. It utilizes an LC oscillator, A CMOS integrated circuit, a tape encoder, and a setback generator.

9. A Countermeasures/Interference Study has concluded that jamming the RF remote-set fuzing system is impractical and interference is virtually impossible. (Reference: (S) Vulnerability of the Remote Set System to RF Interference and Countermeasures (U) by Quest Research Corp. Oct 1976.)

10. Remote-set fuzing system will be low cost. The estimated cost of the fuze will be between $62 and $67 each in quantities of 50,000. The cost of each transmitter/control unit, which will be integrated into the fire control system is $1,000 - $1,500, excluding installation.

11. No modifications to any existing gun, launcher or projectile are required to implement RF remote-set fuzing. Existing munitions can be retrofitted by simply changing the fuze.

12. Installation of the RF remote-set transmitter into a vehicle requires few connections to vehicles' systems. Connections to power, fire control system, and a small, externally mounted antenna are required.

13. RF remote-set system is universal. The same basic transmitter and receiver could be used for the following weapons systems: armor, artillery, rockets, missiles and aircraft.

14. RF remote-set system is well within the state-of-the-art of solid state microwave technology.

15. RF receiver occupies a small volume in fuze.

16. The RF link has the potential for very high data rates.

D4. SHIP PROJECTILES

D4-1. At present, remote setting of projectile fuzes on ships is accomplished mechanically. Typically, the fuze setter is located on a handling tray, and prior to the round leaving the tray and being positioned for ramming into the breech, the fuze setter extends over the fuze and rotates the fuze nose cap to the setting determined by the fire control computer. An example of this setter is the MK27 or MK30 fuze setter used on the 5"/54 MK42 gun mount. A complete description of this gun system is contained in NAVORD OP 3851.

D4-2. In addition to mechanical fuze setters, the Navy has under advanced development (6.3 funding level) an inductive fuze setter for programming the 5" and 8" guided projectiles. This inductive fuze setter is being developed for the Navy by HDL. Basically, the inductive link consists of a primary transmit coil which can be mounted directly on the existing mechanical fuze setter (e.g., MK27/30). A secondary (receiver) coil is wound inside the guided projectile fuze. Power for data storage and 26 bits of data are transferred to the fuze by pulse width modulating a 100 kHz carrier. Verification of the received message is accomplished by alternately opening and shorting the fuze coil at a 4 kHz rate; the pulse width of the 4 kHz signal is modulated according to the stored data message. This signal is reflected at the transmit coil and can be decoded and compared to the message originally sent to the fuze. A complete description of the fuze setter is contained in the appendices.

D4-3. Primarily, the inductive fuze setter was selected for development as the 5" guided projectile fuze communication link. This decision was based upon system design requirements and objectives. Prior to selection of the inductive setter, two other fuze setter technologies were also analyzed and evaluated for potential application. An rf system, although technically feasible, was rejected owing to its incompatibility with existing shipboard rf and radar systems. Also considered was the optical projectile fuze communication link then under exploratory development at NSWC/WOL. This system was rejected in favor of the inductive fuze setter proposed by HDL. Although feasibility of the optical fuze setter had been established and a working engineering model fabricated and demonstrated, a suitable location for the

optical sensors on the guided projectile body could not be established. The photo-cells would have had to have been positioned on the axis of the projectile to avoid a requirement for rotational positioning of the projectile. However, the nose of the projectile was to contain the laser seeker and the rear of the projectile was not accessible. This problem was determined to present a significant engineering risk. In addition, the cost of an optically programmable fuze was projected to be greater than the relative cost of a magnetically settable fuze. Consequently, the HDL inductive fuze setter was decided upon for advanced development. It should be noted that the Navy chose to adopt a fuze setter technology developed by the Army for 2.75" rockets rather than to proceed to advanced development with the Navy optical setter.

D4-4. In regard to development of future Navy projectile fuzes, a description of two on-going efforts is contained in the appendices--Programmable Projectile Fuze and 8" Projectile Fuzing. Fuzes to be developed under these programs will be settable by the inductive link being developed for the guided projectile. This decision was based upon a thorough analysis of Navy requirements and system considerations. Prior to this decision, the other alternate areas of technology designated as "applicable" to shipboard projectile fuze setting were evaluated. These were rf, hardwire, optical, and acoustic. Two significant advantages of the inductive link over the other systems were apparent. One, the inductive system was being developed for the guided projectile and would be required on 5" and 8" gun mounts. By utilizing the inductive setter for both guided and standard ammunition fuzes, the Navy would be able to utilize a single setter which would be common to both the 5" and 8" gun systems and would be compatible with 3" and 76mm gunnery systems. The Navy would then have the potential for a single remote setter common to all gun systems with programmable fuzing capability. The reduced developmental and procurement costs, simplified logistics, and resultant savings in maintenance requirements are obvious benefits of a single setter. The fact that the multi-option remotely programmable fuze (i.e., Programmable Projectile Fuze) will utilize this setter and be certified for 76mm, 3", 5" and 8" guns makes a single setter for these gun systems more attractive. The proliferation of fuzes, presently necessary to meet the different required gun target capabilities, would also be significantly reduced.

D4-5. The second advantage of the inductive link was the minimal modification to present mechanical fuze setters required to install this setter. The transmit coil is bolted on to the existing setter face. It does not interfere with or require that modification be made to the operation of the existing setter. Assuming any setter which would supplant the mechanical setter would be approximately equal in fire control interface requirements, the inductive system can be most readily implemented in comparison with the optical, acoustic, rf, and hardwire systems. A summary of the evaluation of each of these setters and its deficiencies relative to the inductive setter in meeting system requirements follows.

D4-6. The acoustic communication link investigated by HDL in exploratory development and currently unfunded would not be acceptable for ship projectile fuze setting for two reasons. One, the time required for power transmission (1-2 seconds) would not be compatible with the firing rate of either the 5"/54 MK42 or 76mm/62 MK75 gun systems. In addition, no transducer presently exists with a sufficiently broad enough band width to make this system feasible.

D4-7. The rf remote fuze setter in advanced development at ARRADCOM for tank gun application is described in the appendices. This system was rejected primarily due to the interference it might encounter in the shipboard rf environment. Furthermore, the capability of this system to function through the ionized cloud generated by 5" or 8" gun blasts have not been determined. These gun systems could present a more severe environment than that generated by a 105mm tank gun. The adaption of this technology to shipboard gun systems was deemed a high risk effort.

D4-8. Optical remote fuze setting technology was investigated under exploratory development at NSWC/WOL as previously stated. The utilization of the inductive fuze setter for guided projectiles precluded further development of a separate setter for the Programmable Projectile Fuze.

D4-9. Hardwire remote-set fuze technology has also been designated as applicable for ship projectiles. Specifically, the XM587/XM724 electronic time fuze under development by HDL has been proposed for utilization in Naval gun systems. The XM587/XM724 fuze is set with the XM36E1 fuze setter.

This setter requires the operator to dial in the desired fuze function time (or PD) using thumbwheel switches. The setter is then manually placed over the projectile and electrical contact is made between pins located in the setter and three concentric circular contacts on the nose of the fuze. A complete description of the XM36E1 is contained in HDL-CR-75-228-1, Development, Fabrication and Test of XM36E1 Fuze Setter; A. R. Kolanjian, N. L. Sims; November 1975. The setter proposed for use in Naval gun mounts would be modification of the XM36E1 manual setter. Inputs to the setter would be determined by the fire control computer; a mechanical means of positioning the contacts over the fuze would have to be developed. This last requirement is one of several significant reasons the XM587/XM724 was rejected for Navy use. It is highly improbable that a modified XM36E1 could be developed which would be compatible with the existing Mk27/30 mechanical fuze setting system. Other considerations leading to the rejection of this setter include:

a. Development of a modified XM36E1 would then require that Naval gun systems be equipped with three separate fuze setters: the Mk27/30 mechanical setter for fuzes in the inventory, the inductive for guided projectiles, and the XM36E1 for the XM587/XM724 time fuze. A separate fire control interface unit would also have to be developed for the XM36E1. The increased developmental costs for the setter for the XM587/XM724 fuze together with the logistical burden and resultant life cycle cost increase introduced by requiring three separate fuze setters per gun mount does not appear economically sound since a time function will be incorporated in the Programmable Projectile Fuze.

b. A further objection to adopting the XM36E1 for ship projectile fuze setting is the time required by the setter. The XM36E1 requires 1.078 seconds to set the XM587/XM724 to 199.9 seconds and .765 second to set a 100 second option. The 5"/54 Mk42 and Mk45 gun mounts allow only .82 second for fuze setting at their maximum rate of fire (approximately 40 rounds per minute). The 76mm/62 Mk 75 Mod 0 and 1 OTO MELARA has only .51 second available for fuze setting at 80 rounds per minute. Incorporating the XM36E1 setter in these gun mounts would impose a serious limitation on the capability of the 76mm/62, and slight limitation on the capability of the 5"/54 gun mounts.

c. The potential for contamination of the contacts both on the fuze and setter poses a serious problem. Since Navy fuzes are installed in projectiles and stored in drums, corrosion due to salt spray could render them inoperable. A protective coating may overcome this, however, the same corrosion problem on the setter contacts is more serious. These contacts would be in continuous use and a protective coating would be worn off. The setter contacts would constitute considerable engineering and maintenance problems.

d. The XM587/XM724 fuze does not meet MIL-STD-1316 Navy requirements for a Safe-Arm Indication or anti-malassembly feature; it does not meet MIL-STD-1316B Army or Navy requirements for a Safe-Arm Option or anti-malassembly feature. Section 4.4.1 or MIL-STD-1316B states that a fuze must possess an option which (1) prevents assembling the fuze in armed or partially armed condition, (2) prevents installation of an armed assembled fuze into the munition, or (3) assures a positive means of determining the safe condition of the fuze. The XM587/XM724 has none of these options.

D4-10. In summary, present Navy remote setting of fuzes is accomplished mechanically. The development of the guided projectile (which could not utilize the mechanical setter due to seeker location on the nose and power requirements before firing) necessitated the development of a new setter. Two separate setters were proposed for the guided projectile. The HDL inductive setter based on technology developed for setting 2.75" rockets was selected for advanced development over the NSWC/WOL optical remote setter. Two ongoing Navy projectile fuze development programs will utilize the guided projectile inductive setter. Since this inductive fuze setter is completely compatible with the existing mechanical setter, a smooth transition from inventory fuzes to newer, improved, modernized fuzes will be accomplished with a minimum of impact with no loss or modification of present capabilities. Remote fuze setters developed for other than ship projectiles were evaluated and found to have significant disadvantages relative to the inductive setter in regard to Navy gun system requirements. In regard to duplication of effort in development of remote fuze setters, present Navy policy is that a single setter (i.e., the HDL inductive setter) will be utilized by remotely settable projectile fuzes under development.

D.5 DEVELOPMENT FUZES FOR HELICOPTER ROCKETS

Nap-of-the-earth helicopter tactics necessitate rapid engagement of the enemy at various ranges, preferably outside the range of air defense weapons. Remote-set fuzing will, when used with a Stores Management/Fire Control System (SM/FCS), allow the capabilities of the 2.75-in. rocket to be utilized fully, thus increasing the survivability and effectiveness of attack helicopters. A time fuze will be used with any of the cargo warheads presently under development, including multi-purpose submunition, smoke, illumination, and flechette. When an HE warhead would be more effective against the target encountered, the pilot will select rockets with Multi-option (MO) fuzes. The options required in an MO fuze are: impact and delay after impact while a proximity sensor option is desired. These two fuzes would be the only ones necessary for any tactical situation (if the proximity sensor is incorporated), thus reducing the number of fuzes which need to be stockpiled in the inventory. However, the cost effectiveness of including proximity option when not needed, must be considered.

The components of the rocket weapons system used in the Advanced Attack Helicopter (AAH) are the following: Inputs from a laser range finder and other sensors are used by the fire control computer to solve the ballistic equation and to provide a digital representation of the time to function over the target. A setter, which will be located in the SM/ FCS, relays these time data from the computer to the time fuze by coupling through a data link. If a fire control system is not available, the gunner's estimate of the range to target may be set manually. The M/O fuze is also set manually from the setter panel by the gunner from his estimate of the most effective fuze mode. When canopy or bunker delay is selected, the tree height or bunker thickness is estimated, and this estimate is transmitted to the fuze through the setter.

Early effort at HDL on a data link for the 2.75-in. rocket, which would eliminate hard wire connections, concentrated on an acoustic system. This system used a high power transmitter from a commercial ultrasonic welder, and a crystal receiver taken from a phonograph cartridge. The power transferred between transmitter and receiver was adequate when good mechanical contact was made between the rocket and the

launcher. The main drawback of the system was that the data transfer rate was too slow for the up/down counter timing scheme used in the HDL fuze design. For this reason, the inductive data link was pursued at HDL as the preferred method.

An optical data link has not been developed for the 2.75-in. rocket, but could be considered as a possible candidate. An optical system, such as that proposed for the Navy DIMAMS SM/RS system, would use either fiber optic or LED emitters, and photodiode or CCD type detectors. One problem in using an optical system for rockets would be that either the rocket would have to be oriented properly in the launcher tube, or the receiver would have to be sensitive around the entire circumference of the rocket. Another problem is in supplying power to the electronics before the rocket exits the launcher tube. An optical system would have to go through considerable development before it could be used with the 2.75-in. rocket.

The inductive data link and the rf data link were developed by HDL and PA, respectively, as part of competing remote-set fuze systems for the 2.75-in. rocket, and the HDL fuze system was chosen. It is probable that either data link would perform equally well in the field. (HDL had proposed an in-depth technical study of all possible data links, but funds for this were deleted.) Both systems meet the requirements of data transfer rate and setting reliability, while neither system has a return link to verify data. The inductive link includes power transfer to supply voltage to the fuze electronics, and an airstream generator is needed to supplement this induced power for fuze operation. One advantage of the inductive link is that the transmitting field is very localized. A localized transmitting field means that no countermeasure problems of crosstalk between helicopter need to be considered. The disadvantage of the inductive link is that the transmitter coil would have to be included in every launcher,adding to the system cost. In the case of stockpiled launchers, a new front bulkhead containing the coil would be retro-fitted, while for the lightweight launcher presently under development, the coil would be molded into the front of the launcher.

The primary advantage of the rf data link is that no additional components are added to the launcher. Two strip-line antennas, one on each side of the helicopter would

transmit a narrow width X-band beam which would intercept the rockets after they had been launched and had traveled about 3-6m. Holes must be cut in the helicopter nose section, but this is not anticipated to be a problem. A disadvantage of the system is that there is a detectable radiation signature. However, since the transmitter would only be on for a short time, and the beam is directed sideways, the possibility that the helicopter would be detected only from the rf data link is remote. Cross setting of fuzes where the data from one helicopter sets the fuze fired from another helicopter is a possibility which must be considered, but can probably be designed to preclude this.

In summary, the inductive link is a leading candidate for a non-hardwire data link primarily because the HDL system was chosen to go into 6.3 Advanced Development, while the rf system would also meet the performance requirements. The acoustic and optical systems would only be considered if some technical breakthrough was made which gave one of them a significant advantage over the other data links.

D.6 GROUND-TO-GROUND ROCKETS: GSRS

Description of Work: GSRS is a multiple rocket launcher system intended to support cannon artillery in surge conditions by rapid delivery of large numbers of approximately 8 inch free flight rockets. The system includes a self-propelled tracked vehicle incorporating a sophisticated aiming system which helps to achieve excellent accuracy for a free flight unguided rocket.

The rockets will be contained in two 6-round expendable pods which can be rapidly replaced after the rounds are fired. The throwaway launcher pods also serve as shipping containers so that a full complement of six rockets with fuzes is loaded into the pod at the factory, facilitating a hardwire data link and precluding the reloading of each pod. The principal warhead concept is a canister containing a large number of dual purpose HE submunitions. This warhead requires a time fuze to initiate dispersal of the submunitions at the proper altitude. Other warheads being considered include chemical, smoke, scatterable mines and passive terminal guided submunitions.

Three types of remote setting schemes were considered appropriate for GSRS (Ref, chart generated at 3 Mar 1977 meeting). These include hardwire, RF, and inductive data links. Hardwire was chosen for this application because schedule risk was a prime system consideration and an existing (XM587/724) fuze design was proposed.

There were two hardwire approaches suggested, one based on the XM587/724 Time Fuze, and a second based on the XM742 Beehive Fuze technology. The XM587/724 utilizes an MNOS counter/memory with PMOS logic control functions. In the final design three IC packages will be used. One will be the PMOS/MNOS counter and memory, the second will be the time base oscillator and the third, the interface circuitry which allows two-way communication with the fuze.

Advantages of the XM587/724 design are that memory is non-volatile allowing preset and check of all fuzes on the launcher before the launch cycle is initiated and that the permanent memory allows a complete check of the fuze including the timing cycle so that both the memory and the counter

are checked prior to launch. The setting scheme uses a time window which provides calibration of the fuze time base at launch and also resolves any variations due to temperature and long term storage. The XM587/724 utilizes a twin-T oscillator designed so that single point failure modes result in a "fail long" function which enhances overhead safety.

The XM587/724 uses a positive control signal--fuze power--to control the setting in fast time vs. running in real time. Capacitor power supplies must rely on some switch function after launch to provide a control signal. This may lead to down range safety problems in the event of failure.

There are two disadvantages of the XM587/724. One is that the current design requires three IC/hybrid packages. The estimated production cost of these three together is approximately ten dollars. A more complex single chip design would result in perhaps a four to five dollar chip cost. The second disadvantage is that the existing design operates at approximately 20 ma at 24v which requires using a fluidic or chemical power supply rather than a charged capacitor (although there is risk in using a charge capacitor for long flights). However, the fluidic power supply may only cost $3 to $4, somewhat less than the required high quality capacitor, while the generator provides flexibility with its capability for long flights and other functions which may require higher power.

The second hardwire fuze approach was proposed by ARRADCOM for GSRS. This is a single chip CMOS digital timer powered by a charged capacitor. The time base is a crystal tuning fork oscillator. A three wire cable provides power and allows check of S&A safety status, fuze setting and verification. To set the fuze, pulses are transmitted which are counted by the fuze. This count state is read by a shift register and transmitter back to the setter.

Advantages of this system include use of a single chip CMOS counter which may lead to lower cost as stated above and may allow use of a charged capacitor power supply. This of course results in a somewhat simpler design. In addition, CMOS technology has a broader production base than MNOS at this time.

Disadvantages of the system for GSRS application lies principally in the risk in meeting the schedule with a new

IC and a new design concept. The use of a charged capacitor power supply has not yet been proven for the long flight times--so far it has been demonstrated up to 25 sec. The verification scheme utilized for this approach does not test the counter as completely as the XM587/724 scheme in that a complete count is not made after setting. Obviously, some other verification scheme could be chosen but was not suggested for the ARRADCOM approach.

An inductive data link is also considered a viable approach. This was intially discarded for GSRS because of risk. The fuze design for XM587/724 was well established while the 5 Inch Data Link and XM444 (2.75 Inch Rocket Fuze) were just entering 6.3. Using a hardwire link was also considered a safer approach for GSRS. A verification scheme was not used with the XM444 although verification was developed for the 5 Inch Data Link program.

The inductive link system is capable of setting and verifying a fuze with no hard connections. For GSRS the coupling problem is greatly simplified and would be highly reliable because a setting coil can be imbedded in the fiberglass launcher around each tube if necessary, and can be located coplanar with the receive coil to obtain maximum coupling. There might be a reliability benefit since no connector or umbilical cable would be required for each fuze and contact corrosion and damage would be eliminated. The general fuze concept is a one chip digital CMOS IC using a charged capacitor power source for one or two seconds then powered by a fluidic power supply. This is a low voltage, low current fuze which would allow a much smaller fluidic power with greater power margin under worst case conditions. It also uses a time window to achieve self calibration.

The major disadvantage is again risk. As in other capacitor powered logic, the switching from fast time to real time at launch is a safety consideration. The need to provide a setting loop in the launcher is not considered much of a disadvantage.

Since "talk-back" capability is required, the rf link is not a viable candidate for the GSRS fuze.

D7. GROUND-TO-GROUND ROCKETS - SLAMMER VI

The purpose of the Slammer VI System is to provide the user with a mobile ground to ground launch capability, using the 2.75 Inch Rocket System, with the ability to rapidly dispense high rates of firepower. Actual field use of Slammer VI has not as yet been established by the user.

Slammer VI evolved from a concept and prototype hard-wire initiated by the 101st Airborne in coordination with the 2.75 Project Manager's Office. The initial prototype, Slammer II, included two M200A1 19-tube hanging the launchers on a 1/4-ton jeep with a modified mount for hanging the launchers on the jeep. Firing was accomplished using a standard 19-position A/C intervalometer with a 24-VDC power supply (2 12-VDC jeep batteries in series). The first Slammer VI prototype hardware was built in answer to a V Corps requirement identified in Sep 76. The V Corps requirement was initially identified with the Slammer II prototype in mind. However, it turned out that Slammer VI contains more off the shelf, standard hardware, while providing three times the rocket payload than Slammer II. Slammer II payload is 38 rounds; Slammer VI payload is 114 rounds. To date, 8000 rounds of rockets, using 10 lb HE, 17 lb HE, WP HEAD, and inert whds have been test fired at Redstone Arsenal, AL; Ft. Bragg, NC: Yuma Proving Ground, AZ; Ft Campbell, KY, and Ft. Sill, OK.

The Slammer VI System consists of six standard 19-tube M200A1 aircraft rocket launchers mounted on a modified M91 Chemical Rocket Launcher. Modification to the M91 launcher affects only the rocket cluster section. Power is supplied by a 24-VDC or 2 12-VDC batteries. Firing pulse is controlled through a slightly modified standard M119 Rocket Control and Display System (RCDS). The standard M91 sight is used, as it is the traverse and elevation (T&E) mechanism contained on the M91. A small remote firing control box has been specially designed for Slammer VI.

It is highly probable that if the Slammer VI system is pursued and fielded by the Army, system effectiveness will be enhanced by using remotely settable variable time fuzes to optimize warhead functioning at the desired ranges. The fuzes used would be the same fuzes planned for helicopter launched applications, i.e., the M433 and M439 or the follow

on 2nd generation XM443 and XM444 fuzes. The setting system used to set the fuzes would be a combined stores management remote-set fuzing system which most likely would be a modification of the systems planned for use on the Cobra and AHH helicopters.

D8. REMOTE SET DECOYS

HDL participated in a program with NRL called RBOC/ROC, since changed to Sea Gnat. This was a multiple rocket launcher which fires short range 5 Inch Rockets and then functions a decoy warhead. The fuze chosen for an early demonstration test was a single time fuze, remotely set with an inductive link. The feasibility model fuze had adequate space to be fabricated from standard CMOS IC packages such as the RCA 4000 series and was successfully tested. A follow on design will use a single custom IC to achieve small size and low cost.

The Navy uses an inductively coupled motor squib ignition circuit to prevent EMI problems. The squib is inclosed in metal housing at the base of the motor. The housing which contains the firing coil protrudes down into the coil to maximize coupling through the enclosed system.

NSWC and NRL felt that the inductive data link would be compatible with the ignition scheme, while using hardwire connection would pose a problem in launcher design and would tend to reduce the EMI resistance of the system.

Advantages of inductive link are that no connection is needed after reloading and the link can be shielded. Other advantages and disadvantages are similar to those stated for the GSRS inductive links.

A question was raised as to why the XM444 circuit for the 2.75 Inch rocket was not selected for the decoy application. At this time the XM444 program status is uncertain and there is no guarantee that the XM444 IC will be developed. That IC is more complex and costly than required so that unless the XM444 were developed, it would be an unnecessary burden to utilize that IC for the decoy fuze. We have started investigating the IC developed by RCA for the early Beehive (XM742) fuze development. It seems to meet most of our needs including operation with an inductive link and will be studied further. Motorola has stated they are redesigning the IC (they are the XM742 fuze contractor) and we will consider that design when it is completed.

The rf link would be applicable to the decoy problem, but the effect of the rf radiation on board ship would have

to be investigated. The high rf field strengths on a typical combat ship may saturate the simple rf receiver used for the data link, effectively preventing communication. Also, the ship might have four to six launchers (starboard, port, bow, midships, stern), and at each launcher several tubes pointing in somewhat different directions. Thus, antenna alignment could be a problem, unless several antennas are used.

D9. REMOTE-SET FUZING OF UNGUIDED BOMBS

Remote-set fuzing of air launched missiles and bombs is done through high voltage actuation of switches or fuzable links. The pilot's cockpit selector energizes a relay or combination of relays which each connect +300 volts, -300 volts, +175 volts or -175 volts through the electrical umbilical cable. The selection modes are options of a proximity fuze or delays or warhead initiation after impact.

The fuze options are included in the weapon to optimize the warhead effectiveness against a variety of soft and hardened targets. The remote-set capability allows the pilot to select the fuze function which will most effectively destroy the targets as he engages them in the combat area. The four common selections are instantaneous, short delay, long delay and proximity. The proximity fuze detonates the warhead at a factory-set predetermined height above the target. The proximity fuze option is used against very soft surface targets such as radar dishes or nonarmored equipment and personnel. The instantaneous selection detonates the warhead immediately upon detection of the target by the impact sensor. This is used against personnel and light or nonarmored vehicles. The delay option on a fuze has a long and/or short delay which is used against hardened targets such as bunkers and ships. The delays are chosen to allow sufficient time for the warhead to penetrate the target and cause maximum damage.

The basic technology employed in the aircraft-to-weapon remote-set fuzing is through hardwire umbilical connectors. This approach to remote-set fuzing was taken as an added on capability to the hardwire cables which already existed in the aircraft and pylons. The remote-set fuze wiring was added to the weapon power harness to retrofit existing aircraft. The advantages of this approach were a minimum risk since it used an extension of an existing system and it also provided a cheap and fairly reliable system. Also the high voltage system was chosen because the unique voltage signals were not likely to occur from noise sources and cause a safety failure.

The primary disadvantage of this method or remote-set fuzing is that it requires a manual connection of an electrical connector. This is the same method, and often the

same connector, which provides power from the aircraft to operate the weapon. Therefore, it provides an increase in the failure probability proportional to the number of additional wires and/or connectors.

Possible alternatives to the hardwire approach include optical, radio frequency (high and low) and X-ray. Of these technologies neither optical or X-ray were sufficiently mature at the time of the program decisions were necessary.

The rf approach has several desirable features for a communications system. It does not require a physical connection to the weapon. It has a high data rate capability and depending on the physical location of the transmitter it can act as a separation sensor. The disadvantages are that the transmitter and receivers are costly compared with hardwires and that an aircraft operates in a very high EMI, RFI environment. The high EMI environment may increase the probability of fuze failure due to external interference, also, the addition of a possible rf signature source is undesirable.

In addition to the hardwire and rf systems previously discussed, there are three other possible candidates. These are X-ray, inductive and electro-optical systems. The X-ray has the advantages that it does not require a physical connection, is immune from most interferences found in an aircraft system and can be used as a separation sensor. The disadvantages are that it has low data rate and is expensive. The inductive system does not require a physical connection and is fairly immune to interference. Its disadvantages are a very low data rate and the requirement of a close proximity to the transmitter. The optical system has the advantages that it does not require a physical connection and that it can be connected similarly to a hardwire system or included in a hardwire connector. It is highly immune to EMI and RFI and has a very high data rate and the capability of carrying several data channels of different wavelengths in the same cable. Also, the optical system is approximately the same cost as a hardwired system. The disadvantages are that it requires a fairly accurate alignment of the transmitter and receiver and that the transmission can be blocked by an opaque piece of foreign material covering the entire receiver.

D10. COMMUNICATION OF AIRCRAFT TO SMART BOMBS AND GUIDED PROJECTILES

D10.1 Previous Methods

The aircraft-to-weapon communication link is a small but very important portion of the total aircraft electronic control and data systems. In present aircraft the electronics are a collection of black boxes, each having their own wiring harness and interfaces. In many cases the electronic box is added to the aircraft long after the aircraft is built. Since the electronic equipment needs its own cable and interface this necessitates a partial or total rewiring of the affected portion of the aircraft. This is a time consuming and expensive method of upgrading the performance capabilities of the aircraft.

Due to the cost involved in making a hardwire cable change it is difficult to justify altering an entire aircraft model to accommodate any new fuze designs. Therefore, when a system such as the four high voltages for the electrical remote-set bomb fuze is incorporated into several aircraft models it becomes a de facto standard. All future designs for a remote set are then forced to be compatible with the high voltage system or justify the expenditure necessary to modify all the aircraft.

From this, it is easy to see that although the specific aircraft armament system is not under any fuze designers control, it does have an impact on fuze design. The development trends of the aircraft armament systems should be closely monitored by the fuze designers to assure that sufficient provisions are made to accommodate any future fuze systems.

D10.2 Future Aircraft Armament Systems

The armament systems which will be included in some future aircraft designs will be similar if not the same as the present developmental systems. The systems being developed today are for the Navy Advanced Aircraft Armament System (AAAS) and for the Air Force Stores Management Technology (SMT) programs. Both of these programs envision a digital system using either distributed processing or centralized processing architecture. The subsystems in each program will have multiplexed data busses which will be compatible with MIL-STD-1553A and/or MIL-G-85013.

The multiplexed data bus approach to digital systems is swiftly becoming the standardized method of interconnecting equipment. With the increasing sophistication of aircraft avionics and the rapid development of large scale integrated (LSI) circuitry for microprocessors, the use of digital circuitry and multiplexed data busses will increase rapidly. Due to this trend fuze designers will be forced to use multi-plexed data busses in the near future to communicate with the parent aircraft.

D10.3 Communications Systems

The technologies which can be considered for implementation of a digital data communication system are limited by the data rate requirements to rf, hardwire and electro-optical. All three of these technologies are capable of high digital data rates and wide band rates and wide band analog (for video systems) transmission. They can also handle amplitude modulation (AM) and frequency modulation (FM).

These three technologies have basically similar capabilities which are not surprising since they are related physical phenomenon. RF and electro-optical differ only in wave-length. What is important, is the physical equipment necessary to control the signals and the relative advantages in terms of cost, reliability, ease of installation, etc. of each system.

The easiest and cheapest communication system to a weapon, is one that is simply an extension of the aircraft communication system. This type of data interface requires no interfacing circuits and connects to the data bus just link any other piece of equipment. This would do away with the need to add relays, transmitters or interface circuits to the aircraft and involve only a software change to add any new weapon. This type of system would provide digital data communication between the aircraft and weapon and require at most, only the addition of a specialized connector.

D10.4 Integrated Communication Systems

The integration of all equipment and weapon communication systems into one, requires that the physical characteristics of the data bus be compatible with the aircraft environment and physical construction. The decision of which

system to use does not significantly affect the layout of cable routing in the aircraft. Coaxial, twisted pair, and fiberoptic cables can be pulled through the same holes or conduit, hardwire line drivers and receivers are plug in interchangeable with LED or laser diode transmitters and photodiode receivers, while the rf system utilizes a small solid-state transmitter and antenna unit at its control cable termination. Hence, hardwire and electro-optic systems can replace each other or even be mixed if their particular characteristics are more advantageous for a given requirement. The following is a comparison of hardwire and electro-optic characteristics to aircraft and weapon communication requirements.

Physical Characteristics	Electro-optics	Hardwire Twisted Pair
1. Bandwidth	Very High (DC to 200 MHz)	High (DC to 1 MHz) Caox (DC to 10 MHz)
2. EMI Resistance	Extremely High	Low to Moderate
3. Crosstalk Between Lines	Zero	Moderate
4. Size of Cable	3/16"	1/4" to 3/8"
5. Weight	Extremely Light	Light
6. Crush Strength	High	Extremely High
7. Bending Radius	Equal to Twice Diameter	Equals Diameter
8. Sparking Danger if Broken	Zero	Moderate
9. Free Air Transmission	Good	Zero
10. Ease of Redundancy	Good	Moderate
11. Ease of Repair	Poor	Good

AIR LAUNCHED MISSILE AND SMART BOMBS
FROM FIXED WIND AIRCRAFT

There are presently seven (7) air launched missiles and smart bombs with remote-set fuzes. The basic method of setting the fuzes is the same for all of these weapons. They differ only in the number of options and proximity fuze capability. The following is a list of the weapons and fuze options:

Weapon	Fuze Options			
	Instantaneous	Short Delay	Long Delay	Proximity
MAVERICK	X	X	X	
WALLEYE I	X		X	
WALLEYE II	X		X	
BULLDOG	X	X	X	X
BULLPUP	X	X	X	X
HARPOON		X		X
CONDOR	X		X	

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APPENDIX E

DEPARTMENT OF THE AIR FORCE
AIR FORCE ARMAMENT LABORATORY (AFSC)
EGLIN AIR FORCE BASE, FLORIDA 32542

REPLY TO
ATTN OF: DLJF

14 April 1977

SUBJECT: Data Requirements for Remote Set Fuze Study

TO: NWC, Code 3353
ATTN: Mr. Dick Swenson
China Lake CA 93555

1. I have reviewed past and present Air Force activities and future plans to identify efforts in basic remote set technology. None were identified. The only Air Force development program directed to a specific weapon system utilizing remote set fuzing was the FMU-112/B Impact Short Delay Fuze. The FMU-112/B was designed to be compatible with the Navy AN/AWW-4 Fuze Function Control Set (FFCS) and did not include any work in basic remote set technology.

2. Recent Air Force decision not to incorporate the AN/AWW-4 or equivalent FFCS in the A-10 and F-16 aircraft effectively eliminates remote set fuzing for Air Force air delivered munitions for present generation aircraft. The advantages/disadvantages of remote set fuzing continue to be discussed in Air Force circles. However, if and when the Air Force adopts remote set fuzing for air delivered munitions, the technique selected will probably include either direct "hard wire" optical or electrical communications. Therefore no specific Air Force basic remote set technology efforts are anticipated.

3. A related activity which ultimately could impact on the Air Force/Navy remote set fuzing commonality question is in the area of future Stores Management Systems. Both the Air Force Armament Laboratory (AFATL) and the Naval Weapons Center (NWC) under a MOA are pursuing Stores Management Technology efforts designed to provide the following:

a. Specifications and plans for full scale development of stores management systems for specific (designated) aircraft applications,

b. technical reports and data resulting from analysis, design studies, and experiments, and

c. the definitization of a standard store interface.

Robert C. Erhart
ROBERT C. ERHART
Air Force Member
Remote Set Fuzing Ad Hoc Committee #2

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